
METAL PROGRESS

Metal Progress

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Ernest E. Thum, Editor

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At Tenerife, Canary Islands, in 1902, J. F. T. Berliner was born. He attended George Washington University from 1918 to 1926, receiving successively the degrees of B.S., M.S. and Ph.D. He has been with the Bureau of Standards and later in the Bureau of Mines. Since 1929 he has been with DuPont Ammonia Corp. His article on ammonia dissociation is on page 39.

The account of magnesium which appears on page 33 was written by Dr. John A. Gann, chief metallurgist for Dow Chemical Co. Dr. Gann has been closely associated with the development of this metal. In recent years he has been chiefly concerned with the production of strong, light alloys of magnesium.

On page 57 is a description of an instrument for recording the roughness of machined surfaces. This was written jointly by F. A. Firestone, assistant professor of physics, University of Michigan; F. M. Durbin, formerly assistant investigator, Department of Engineering Research at the University; and E. J. Abbott, research physicist in the same department.

The uses of metallic calcium are told on page 60, by Charles Hardy and Charles L. Mantell. Mr. Hardy, president of the Hardy Metallurgical Co., New York City, was born in Wandsbeck, Schleswig-Holstein. Metallurgical pursuits have taken him to 40 countries. Dr. Mantell is a graduate of McGill University and received his Ph.D. in chemical engineering at Columbia. He is now consulting chemical engineer and metallurgist and is professor of chemical engineering at Pratt Institute in Brooklyn.

W. V. Morrow, whose article on metal furniture begins on page 27, is a graduate of Kenyon College. He has had much newspaper experience and for the last ten years has edited trade magazines in the furniture field.

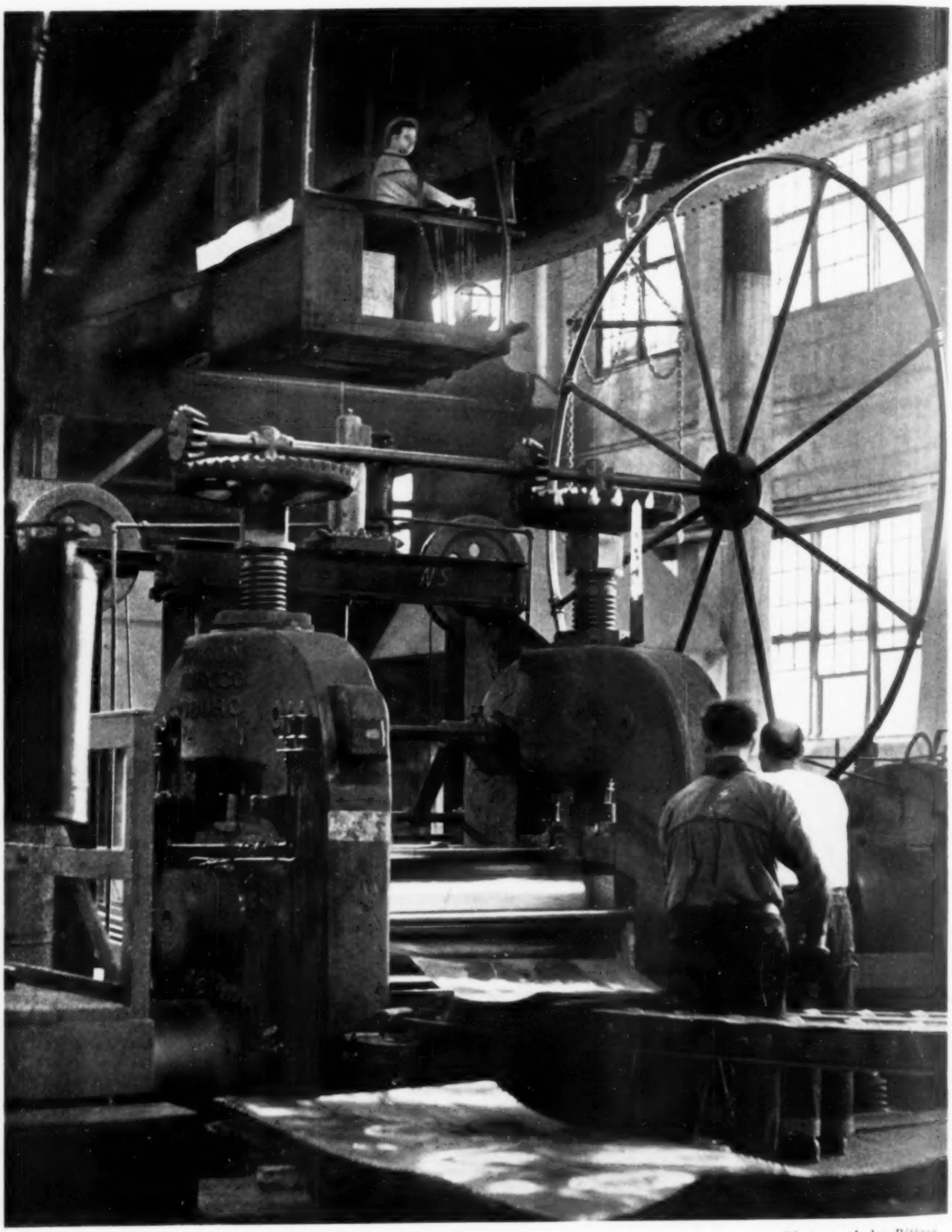
From England comes the article on hardening by magnetism on page 52. E. G. Herbert, the author, is well known for his pendulum hardness tester and the "cloudburst" process of superhardening.

Charles Hardy

C. L. Mantell

J. F. T. Berliner

W. V. Morrow



Photograph by Rittase

Metal Furniture Needs Fine Sheets

Fine Finish on Metal Furniture

By W. V. MORROW
Jamestown, N. Y.

Photographs Courtesy of
Art Metal Construction Co.

. . . MUCH CREDIT IS PROPerly given the automotive industry for insisting on better qualities in deep drawing sheets, but it is not so widely known that a similar movement was started years before by pioneers in the metal furniture business. When the latter industry had its beginnings, the products of the sheet steel industry consisted largely of black, galvanized, and tin-coated sheets. Requirements for smooth surface and forming qualities were not exacting nor even well understood at that time.

Aware of the limitations of these materials, Cyrus E. Jones, pioneer in the metal fabrication industry and at his death executive head of the Art Metal Construction Co., Jamestown, N. Y., called in the president of one of the steel producing companies and showed him the difficulties the factory was having with black sheets. The two of them worked out a rough specification for ductility and surface and provisions against other imperfections which might be overcome by the manufacturer. This was the start of countless experiments which eventually produced a steel sheet free from much of the trouble previously experienced, particularly in the scaling of finish.

This early cooperation between steel producer and steel furniture fabricator later proved a boon to the automobile industry. By the time that great industry turned to steel for its body work, many of the early difficulties in forming, drawing, and finishing steel sheets had been overcome. Of course, great improvements have been made in recent years in the art of rolling sheet steel and drawing it into useful machine parts, and these improvements have enabled the furniture manufacturers to shape their product for many purposes, and express in the desk, the refrigerator, the kitchen cabinet, and hundreds of other articles the dominant spirit of power, grace, and strength which steel conveys to the human mind.

A traveling man who sold to courthouses is credited with first implanting the idea for the use of steel for filing cabinets. Observing the dilapidated condition of the wood boxes in one of the courthouses he visited, he remarked that if the boxes were fashioned from tin-coated steel sheets, properly riveted together, they would give longer and more satisfactory service. Someone took up his idea and soon the Fenton Mfg. Co., predecessor of the Art Metal Construction Co., was established and began turning out metal files. Today there are a dozen plants making steel furniture products of one type or another centering in Jamestown, N. Y., while Youngstown, Canton, and Cleveland in Ohio, Aurora, Ill., Rochester, Buffalo, and New York, N. Y., have notable plants whose output, until very recently when all business declined, showed a steadily mounting yearly volume.

Aside from fine carvings, practically everything that can be made from wood can today be produced from steel sheet. Finishes have been discovered that are beautiful as well as

Multiple Pointed Electrodes Put Three Spot Welds Simultaneously in One Joint Where Formerly One Rivet Had to Suffice. Greater rigidity and strength are thus secured

durable, and that satisfy the esthetic temperament of the most sensitive artist. Even the "cold feel" of the material, an objection more psychological than real, has been overcome, as will be pointed out below.

Potential Consumption of Steel

An inquiry conducted about a year ago by the National Association of Flat Rolled Steel Manufacturers indicates a promising future for the industry. Office desks then consumed about 22,000 tons of steel annually; if all wooden desks were made in steel it would require no less than 1,100,000 tons. Shelving and letter files each consume about 70,000 tons of steel annually; if all shelving now carpentered of flimsy boards were made of permanent fireproof steel, over 1,000,000 tons would be needed. Steel refrigerator bodies are more and more common; kitchen cabinets represent a field hardly touched. Each is a potential outlet for 700,000 tons of sheet annually. Visualize the possibilities and market for steel in household and hotel furniture, and the opportunity for expansion seems limited only by the salesmanship of the promoters.

The sheets used for desks, for filing equipment and like articles go under the trade name of "furniture steel sheets," a uniform, high-grade open-hearth sheet with carbon 0.05 to 0.10%. It is reannealed to permit flat bending without a crack, full pickled to remove scale and all surface impurities, cold rolled for surface, stretcher leveled, resquared, and finally oiled to prevent rusting.

There is a wide divergence of fabrication methods employed by different furniture plants and even by a single plant that produces a variety of articles. Some parts are formed quickly and easily, while others necessitate a series of complicated dies and require a sheet capable of an extra amount of cold working in fabrication.

Considerable strip steel is also used for drawn shapes and stampings requiring narrow bands of metal. Drawer suspensions are made of either cold rolled or cold drawn steel bars held to very close size tolerances.

Most of the troubles encountered with sheets are with the heavier gages, some of which crack in the forming operations. If the metal is not sufficiently free from scale, difficulty is encountered in spot welding. Trouble also occurs if the steel varies in thickness. If it is too heavy, it will not bend properly and will overstrain or stick in the dies.

The greatest care is exercised by the fabricator in selecting only the best sheets for desk sides, panels, and other similar purposes. This steel is stretcher leveled and resquared and is handled as little as possible after coming from the mills in order to avoid bending. In the factory, it is often necessary to hand level the sheet in order to make it absolutely flat. A

very smooth surface is desired in order that the minimum of "filling" be used to fill the small surface pits up to a polished surface.

Good design, proper reinforcement, and modern construction methods are the chief assurances that desk or table tops will keep smooth and flat permanently. A large majority are covered with battleship grade linoleum. Some of these are beautifully grained in walnut or mahogany to match the finish of the entire piece. These grain finishes will retain their good appearance indefinitely.

The "hollow sound" of thin metal construction has been eliminated by numerous concealed reinforcements that brace the piece so that there are no large unsupported areas. Sound deadening insulation is not necessary in properly constructed desks and filing cabinets. While some manufacturers use felt asbestos strips or sheets in the sides and back panels of desks, they do it principally to meet a sentimental criticism. Without these, knuckles rapping the panels will produce a "metallic" sound, but this is not the usual practice of the person who works at the desk, or of his callers. Drawer heads and desk tops give out a more solid sound because of reinforcing members placed in the top and proper flanges formed in the heads.

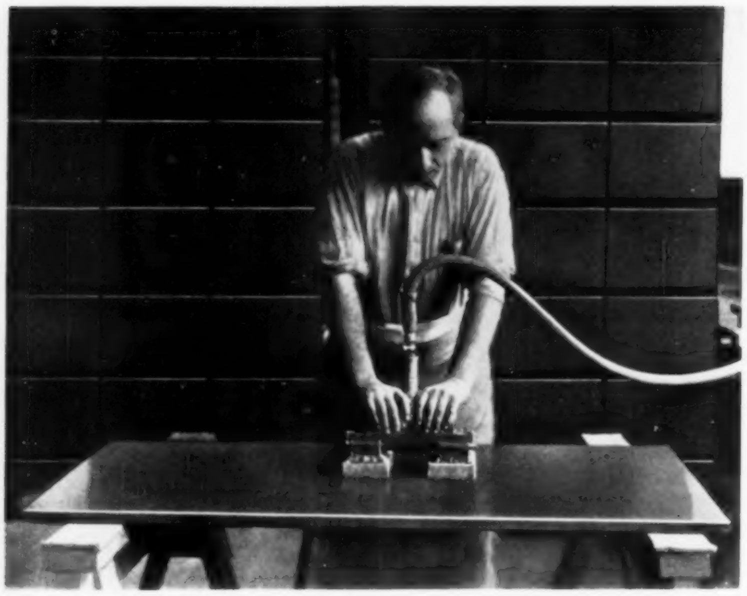
In general, all steel furniture products pass through several separate classes of operations: Layout, notching, bending, layout for welding, assembling, welding, surface finishing, final cleaning, inspection. The two most interesting of these are welding and finishing. While the most of our attention will be given to the latter, it should be mentioned that welding is a joining operation which is fundamental to the whole industry — it simply could not exist if the metal had to be joined by rivets, screws, or solder.

Arc Welded Parts

At the present time, 90% of all welding at the Art Metal Construction Co. is done with the electric arc in one of three forms. Lap joints in sheets or frames are done by spot welding. Tubes forming legs and braces also are butt welded together by resistance methods. Butting seams in sheets and corner joints are made with electric arc. For thin sheets, where the heat of the arc tends to burn through, the oxy-acetylene flame is necessary. All these joints must be carefully ground to remove excess welt metal or flash down to the general level of the surface.

Grinding joints on surfaces or edges which are to receive an enamel or lacquer finish, while it must be carefully done, is not as exacting an operation as though the metal were bronze or aluminum or a polished steel surface which is not to be covered with opaque pigment. A bronze or aluminum piece, for instance, must be carefully ground on the emery wheel and afterwards belt-sanded. It is impossible to do any filling, and if there are indentations the metal must be raised. Seldom is it necessary to sand the joints of steel articles. Great care in handling polished metals does not always prevent scratches and sometimes it is necessary to polish out a scratch in polished aluminum or bronze, and when this occurs it slows up manufacturing operations. However, such occurrences are exceptions. Before finishing, all

A Series of Locking Levers, Racked for Easy Handling, Is Reinforced Slightly at One Point by an Oxy-Acetylene Weld



Drawer Heads, Table Tops, and Exposed Ends Are Rubbed to a High Polish With a Pneumatic Device, Guided by a Skilled Workman

joints must, of course, be cleaned in a benzine bath to wash off all dust and grit.

This brings up the finishing process, which, from a merchandising point of view, is most important, as "eye appeal" is the factor that determines most sales. The American people are notably style conscious in their office furniture as well as in their clothes, automobiles, and the pets they adopt. From a merchandising and manufacturing point of view, the finish is so important that about 15% of the time devoted to making steel furniture is consumed in that operation.

Finishes must combine beauty with durability; they must not crack, peel, nor chip, and under ordinary usage should never need retouching. The high standard of steel sheets has helped the finisher realize these objectives.

When the formed steel sheet or assembly starts its journey through the finishing process, it goes through these operations in sequence: (1) Cleaning, (2) sanding, (3) primer coat, (4) baking, (5) testing, (6) sorting.

At this point, those places which will be concealed when finally assembled are separated from those which will be exposed to view. The latter pieces then continue through a further processing as follows: (7) Filling, (8) baking, (9) sanding, (10) second coat, (11) baking, (12) sanding, (13) cleaning, (14) final coat, (15) baking, (16) rubbing, (17) graining, (18) varnishing, (19) baking, (20) rubbing.

Special finishes or enameling will increase the number of coats as well as the number of times the piece has to be sanded, baked, and rubbed.

Cleaning is usually done in benzine to remove all grease and oil. It is then very important that the sanding be thoroughly done, for if rust, no matter how minute in quantity, remains on a sheet of steel, it will spread with age, and in time will raise the color and flake off. It will appear as though acid were eating its way out of the metal.

When the metal is ready for the primer coat, the operator handles it with cotton gloves to prevent contact with perspiring hands. The organic compounds coming from skin pores mark or rust the steel, and lay the foundation for rust. The first or primer coat is applied either by dipping (if the piece is of proper size), air brushing, or hand brushing. In any event, the operator must make certain that every part, inside and out, is thoroughly coated. The piece is then put into an oven and baked for five hours, usually at 250° F.

Finish Severely Tested

Provision is usually made in metal plants for testing the finish after baking. Tests are made on small samples of steel which follow the regular finishing routine. After baking, these samples are bent at sharp angles and hammered; the finish must not flake nor show creases. If one of these pieces flakes, the operator thoroughly inspects the larger pieces and may repeat one or more of the preceding processes to discover the trouble and correct it.

The material which will be exposed to view requires further processing, and is then worked over by a skilled artisan with filling material and broad putty knife. He fills any crevices in the steel with a plastic mixture of pigment, clay and oil, and the piece is rebaked for five

more hours at the same temperature as before. More bending and flaking tests are made on samples; the filler must not be brittle. Pieces are then thoroughly sanded and the next color coat applied either by air or hand brushing, depending upon the class of work. This coat is also baked.

Two-coat work is then sanded with fine sandpaper or emery cloth in order to produce a smooth, even surface. It is cleaned with chamois skin and compressed air to remove dust and specks and is delivered to the finishing room for the final coat which is usually brushed on and baked at the same degree of heat as the previous coats.

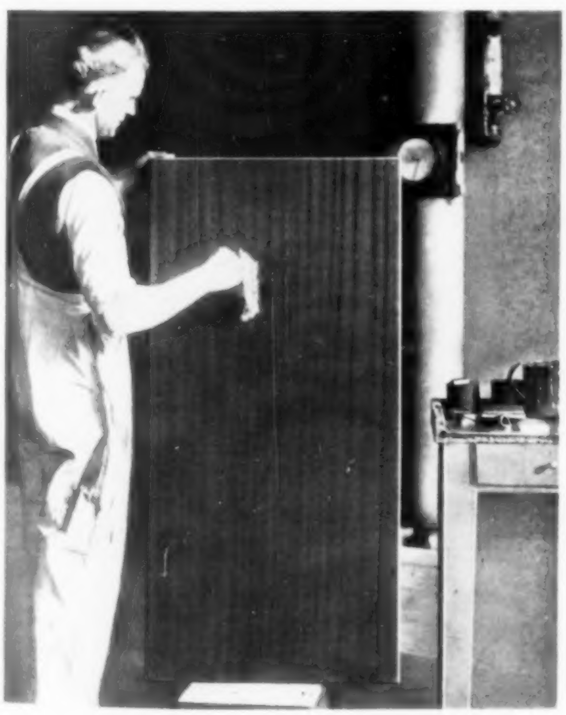
Three-coat work, after removal from the ovens, is passed over to the rubbing department where it is rubbed with fine pumice stone and oil until perfectly smooth, after which it is sent to the assembling department.

If the piece is to be grained to simulate wood, the same operations of dipping, sanding, and filling are followed as for the plain colors, but in order to match the natural wood accurately, it is important that the ground coat and graining colors be mixed to the correct shade. To determine these shades, it is necessary to bake out and grain small samples to match the color exactly.

Graining is a hand operation and requires the services of skilled artisans. After the color has been applied, the metal is baked and then rubbed with a hair brush in order to remove all specks before the varnish is applied. Then two or three coats of varnish are put on, each one baked and, after baking, rubbed.

Sectional Cabinets Are Designed so a Number of Units of Drawers of Different Sizes Can Be Assembled by Concealed Bolts and Clamps. Interchangeability is one characteristic of non-warping steel units, properly made to close dimensional tolerances

Hand-Grained Finishes Represent Craftsmanship of High Order and Are Matched Only by the Finest Selected Woods



Crinkle Finish for Warmth

The objection is sometimes heard that steel for desks, chairs, and other office equipment is objectionable because it has a "cold" and "clammy" feeling. Actually a wood desk and a steel desk in the same room (with no air currents) are at exactly the same temperature. The sensation of coolness of the steel desk comes from the fact that steel is a better conductor of heat and also has a high thermal

Crinkle Finish, Developed as a Characteristic, Non-Imitative Surface for Steel Furniture, Has the Added Merit of Avoiding the Cold Feeling of Steel With Smooth Lacquered or Enameled Finish. Photograph, courtesy General Fireproofing Co.

capacity, so that when any portion of the body comes in contact with it, heat flows from the body to the desk.

There is a greater area of the fingers or portion of the hand in contact with a smooth enamel surface than when a somewhat rougher wood surface is touched and the sensation of coolness is intensified by this condition. One of the leading manufacturers, the General Fireproofing Co., has developed a "crinkle finish" which does not have a cold feeling (although it was not originally developed for the purpose of overcoming the sensation of coolness which seems to be overstressed by those who can find nothing else wrong about a steel desk!) This finish was developed, along with others, in order to give the steel desk an identity of its own and about which there could be no suggestion of imitation.

The crinkle finish is rough enough to form air pockets between the skin and the surface it touches, thus affording a comparatively small area of contact. In addition, the insulating effect of the enamel is greater because it is considerably thicker at the raised points. This finish feels the same as wood or any other "warm" material.

The crinkle is produced in the second coat. A priming coat is sprayed on and baked, giving the usual flat surface. The crinkle coat is then sprayed on; it also is smooth when applied, but it crinkles in the baking process. The finish coat may be any color desired, either plain or mottled.

At the present time, most of the demand is for reproductions of wood effects. However, there is a growing school among architects and interior decorators asking for finishes which reflect the distinctive qualities of steel. They believe like Plato that "beauty is the splendor of truth" and that the finishes on metal should reflect the intrinsic merits of the material and not be imitative of another medium. This movement encourages the fabricator in bringing forth new finishes which will help promote steel for office and household equipment.

Magnesium

Growth of an American Industry

By JOHN A. GANN
Chief Metallurgist
Dow Chemical Co.
Midland, Mich.

From an address before
Institute of Metals Division
A.I.M.E., February, 1932

. . . MANY OF OUR METALS were known to ancient men and their development has paralleled the advance of civilization. Magnesium, however, is one of those metals that within the space of a very few years has sprung from a technically unknown, little appreciated, and expensive material to front page importance in many fields of engineering.

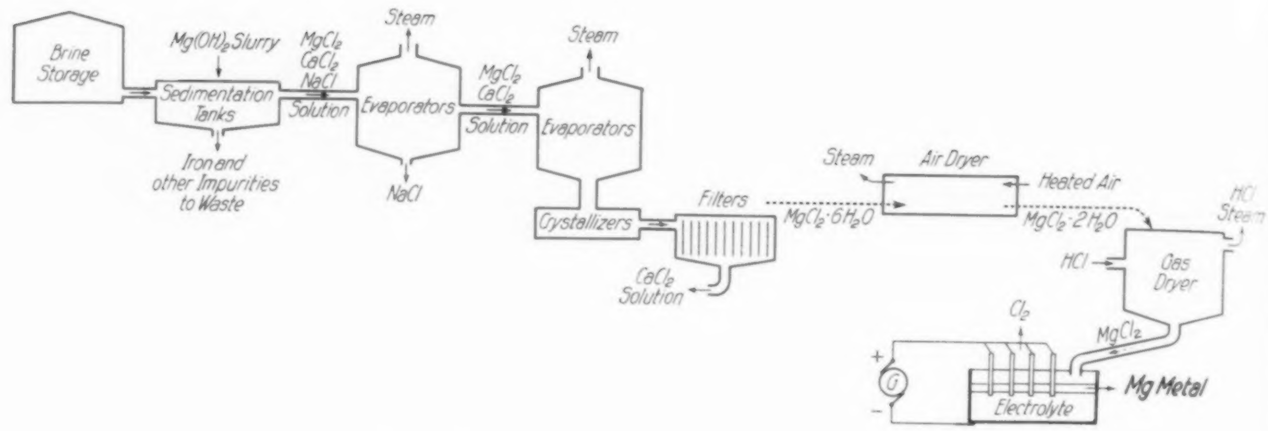
The earliest recorded attempts to produce the metals are those of Sir Humphrey Davy. He was able to prepare an amalgam, but did not obtain the pure metal. Success finally crowned the efforts of the French chemist, Bussy. In 1830 he obtained substantially pure magnesium by fusing anhydrous magnesium chloride with potassium. A commercial process was developed from this reaction by substituting sodium for potassium and was put into operation in France, England, and the United States (Boston).

Bunsen may be considered the real founder of our present magnesium industry. In 1852, he prepared this metal by the electrolysis of fused magnesium chloride in a porcelain crucible. Inverted pockets cut in the carbon cathode served as collectors for the molten magnesium, since otherwise the metal rose to the surface of the fused bath and burned. In 1886, the first electrolytic magnesium plant was installed near Bremen, Germany, and about ten years later the Chemische Fabrik Griesheim Elektron undertook the production of the metal.

The electrolytic process was soon recognized as superior to the chemical reduction methods with the result that Germany became the world's chief producer. National defense requirements, occasioned by the outbreak of the World War and the cutting off of imports, caused France, England, and the United States again to take up the production of this metal. Our American magnesium industry therefore dates from 1915, since the earlier Boston enterprise had long since been discontinued. In 1917, there were five producers, but by 1920 only two remained, namely, The American Magnesium Corp. and The Dow Chemical Co. In 1927, the former ceased the manufacture of ingot metal.

The Dow Chemical Co.'s entry into the magnesium industry in 1916 was due primarily to the abundance of magnesium chloride in the salt brine that forms the basis of its various chemical processes. A method for the commercial extraction of this salt had been developed and it was placed on the market just when the War suddenly stopped importation of German magnesium. The local product thus became the raw material for many of the companies then beginning the production of the metal.

It was soon recognized that two great problems still remained, namely, a way to convert magnesium chloride into a more practicable cell-feed, and an electrolytic cell. These two problems were attacked simultaneously by different groups of workers, since the progress in one often depended upon the success of the other.



Flow Sheet of the Present Method of Converting Michigan Brines Into Anhydrous Magnesium Chloride, Previous to Electrolysis of Metal

Two names are indelibly engraved in this work, namely, Dr. Herbert H. Dow, late president and general manager of our company, and E. O. Barstow, one of our production managers. Endowed with unswerving determination, perseverance, and faith in the ultimate outcome, they bravely met adversity and repeatedly proved that necessity is the mother of invention.

Magnesium chloride normally contains six molecules of water of crystallization, which correspond to more than 50% of its weight. Introduction directly into the electrolytic cell would result in a very low operating efficiency. A portion of the water would be decomposed by the current, and another portion would instigate a number of very undesirable chemical reactions. Direct heating, to remove the water by drying, decomposed a portion of the chloride into magnesium oxide. This necessitated indirect dehydration methods.

The first method chosen was the so-called sal ammoniac process. This consisted in evaporating a solution of ammonium chloride and magnesium chloride to crystallize out a double salt having the formula, $MgCl_2 \cdot NH_4Cl \cdot 6H_2O$. This salt could be air dried to remove about five molecules of water without much decomposition and the final dehydration then effected by fusing the air-dried salt.

After having made a few pounds of this product in hastily improvised equipment, attention was directed toward its electrolysis. The first cell consisted of a small rectangular box welded out of boiler plate. This was lined with slabs of soapstone and a soapstone partition divided the box into two compartments at the top, leaving the lower portion of the interior open for the whole length. An iron plate was inserted in one compartment and a graphite rod in the other and these two electrodes connected with a direct current low voltage generator. The top of the cell was covered with soapstone slabs provided with openings for the electrodes. This crude cell was heated in a brick arch until it was thoroughly hot; molten magnesium chloride was then poured in and the current turned on.

Much to our surprise the cell actually "ran" when it was first started and began to produce magnesium metal which appeared as small globules floating in the molten salt bath. The current was approximately 120 amp. at a potential of 10 to 12 volts. This power input maintained the salt bath in a molten condition at a bright red heat.

Continued operation of this cell taught several important lessons. The addition of common salt to the magnesium chloride not only lowered its melting point, but also increased its conductivity. A little fluorspar helped to coalesce the small globules of molten magnesium. It was also discovered that the best way to remelt the magnesium was to use some of the fused cell bath as a flux. This procedure, with certain refinements, forms the basis of present-day melting and scrap reclamation processes.

After the first experimental cell had been operated for some weeks a semi-plant unit was constructed. This consisted of a 400-amp. cell and setting, a low voltage motor-generator set, a brick furnace and subliming chamber for the

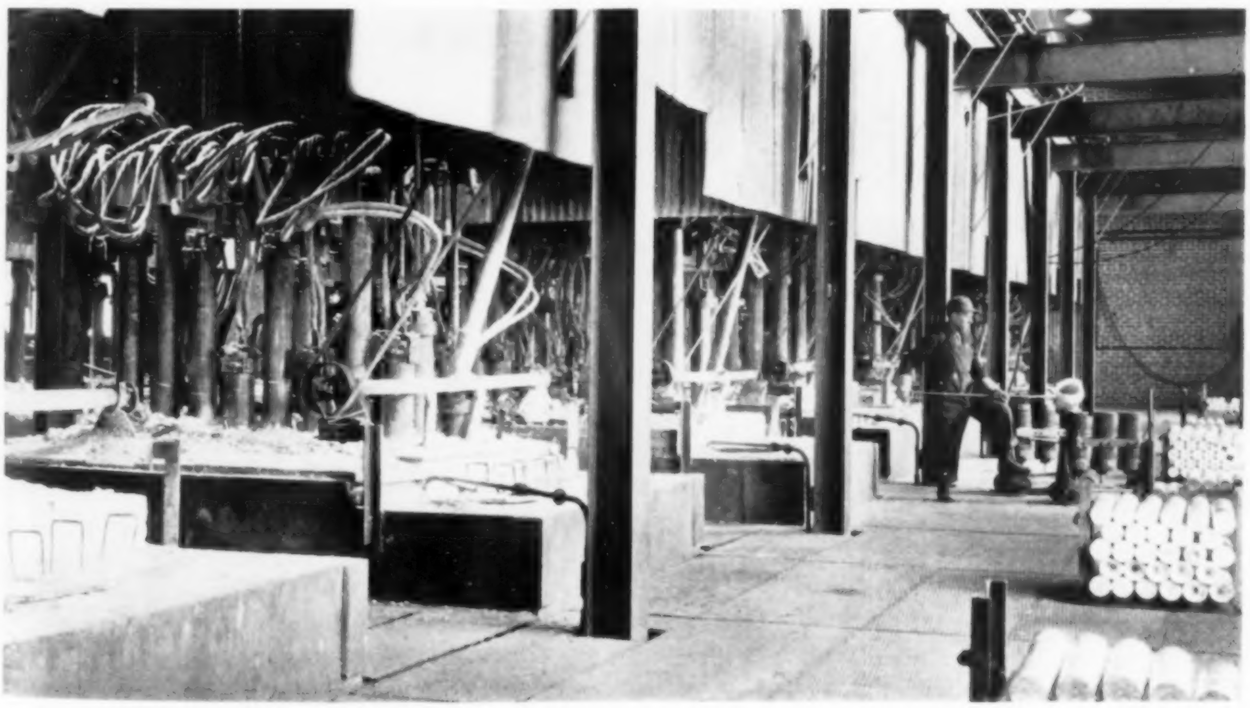
production of anhydrous magnesium chloride, and a pot for remelting and purifying the magnesium. This unit was operated more or less continuously for several months with varying success. When things went smoothly, as much as 10 or 12 lb. of metal was made in a day; at other times polarization of the anodes caused considerable trouble. The remedy for this was simple enough after once discovered. It consisted in maintaining the cell bath in a suitably fluid condition by holding the proportions of magnesium chloride and sodium chloride between the limits of approximately 40 to 60% of each. Escape of chlorine was another difficulty; sometimes it persisted in boiling out of the anode compartment and drove everyone out of the building.

This work continued on into the winter of 1916-1917 through a wet and soggy fall. The building became well saturated with magnesium chloride which had volatilized out of the cells and melting pot and settled on the surface of everything. Here it immediately commenced to absorb water and in a short time everything in the building which could not be kept warm was covered with a dirty, slimy coat of magnesium chloride.

Despite this, progress had been steady and the time arrived when it was decided to build a commercial plant. Accordingly, the engineers and chemists got busy with pencil and slide rule and soon some very fine designs for a plant appeared on the drafting board. After several months, a large building was erected and the equipment installed. It was a fine job of construction and it should have worked perfectly.

After a sufficient supply of anhydrous magnesium chloride had been accumulated the work of starting the cells began. There were 25 cells in series, each holding 300 to 400 lb. of molten salt and kept hot by oil burners. There was some confusion before all were filled, but finally everything was ready and the current turned on. It was not long before difficulties began to develop. Some of the cells became too hot, while others persisted in freezing up. Some of the cells were short circuited by the accumulation of metal in them. Chlorine leaks made the air almost unbearable. Finally a few cell-pot cast-

Battery of Magnesium Cells. Steel tank is cathode; graphite electrodes are anodes. Electrolyte is a fused mixture, principally sodium chloride and magnesium chloride. Latter is fed continuously through inclined pipes at front. Magnesium metal is ladled out of the forebays and poured into air-cooled molds



Chairs, Made of Strong Magnesium Alloys, Have Artistic Merit and Great Utility

ings cracked and allowed the molten charge to run out on the floor. Nothing could be done but cut out those cells and continue with the survivors. Herculean efforts failed to keep the plant in condition and a shut-down resulted.

Such experiences taught many lessons about the design of a better cell and also showed that the sal ammoniac process for producing magnesium chloride was beset with many obstacles. It was therefore decided to abandon this process and dismantle the plant. This was the state of affairs at the time the writer first visited the Dow plant!

The next cell developed was both simple in design and a success, since it could be operated for weeks at a time. It consisted of a round-bottomed, cast steel pot that served as the cathode. A large graphite electrode was suspended centrally in the pot and a fireclay flue liner, surrounding the anode, formed a chamber for collecting the evolved chlorine gas. This cell held 800 lb. of salt bath, operated on 3000 amp. current, and produced 50 to 60 lb. of magnesium per day in continuous operation.

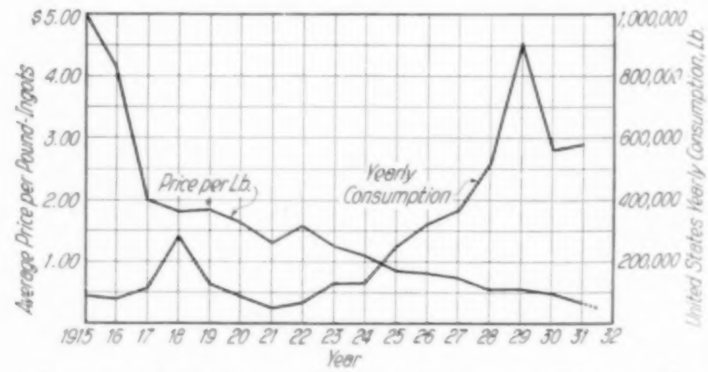
Feed was made by the "double salt" method: Hydrated magnesium chloride was carefully air dried until approximately four of its six molecules of water had been driven off; it could then be melted with an equal weight of sodium chloride at a temperature well below the melting point of the pure salts, thus largely preventing decomposition.

This "double salt," used as a cell feed, caused an accumulation of sodium chloride in the cell (since only magnesium chloride was consumed during electrolysis) and the bath became sticky and viscous. Continuous operation, therefore, necessitated periodic transfer of part of the cell bath back into the fusion kettle and replenishing with fresh feed.

Success of this new cell soon prompted the construction of a new plant. A few cells started off propitiously and soon all were producing metal. Operating difficulties were multiplied considerably when we attempted to control the bath composition in the large number of units by this periodic dipping method. Nevertheless, the plant was operated for several weeks at a current efficiency of 60 to 70%.

The finish of this second plant came with almost dramatic suddenness. One morning one of the large fusion kettles cracked open and spilled its charge of hot molten salt across the floor. Wooden roof supports and working platforms were immediately on fire and in a few minutes the entire building was ablaze. The only thing salvaged in undamaged condition was a pile of magnesium ingots.

This catastrophe came as another serious set-back in the slow and faltering progress of magnesium manufacture at Midland. When the curtain finally did rise again we had another



Cost of Magnesium Comes Down as Consumption Goes up. Amount used for castings and fabricated articles has been substantially constant in 1930 and 1931

series of four or five of the 3000-amp. cells, this time thriving on a feed of anhydrous magnesium chloride instead of the mixed chlorides, thus eliminating the dipping evil. This material was the product of another extensive research, and was prepared from the hydrated salt by partially drying the latter in air and completing the dehydration in an atmosphere of hydrochloric acid gas.

From an etching by O. Kuhler

We still had difficulties, as evidenced by the frequent escape of hydrochloric acid — and a mixture of hydrochloric acid and chlorine gases cannot be recommended to anyone as an atmosphere in which to work! The cells, however, were kept in continuous operation for a period of months and required relatively little supervision or operating labor. It therefore began to look as though we had at last evolved a practical working plant for large scale manufacture.

This time progress was slowed up, not by operating difficulties but by the financial crash of 1920. Curtailment was followed by a complete shut-down; we then had on hand the magnificent amount of 20,000 lb. of magnesium, which proved sufficient to meet all requirements for over a year.

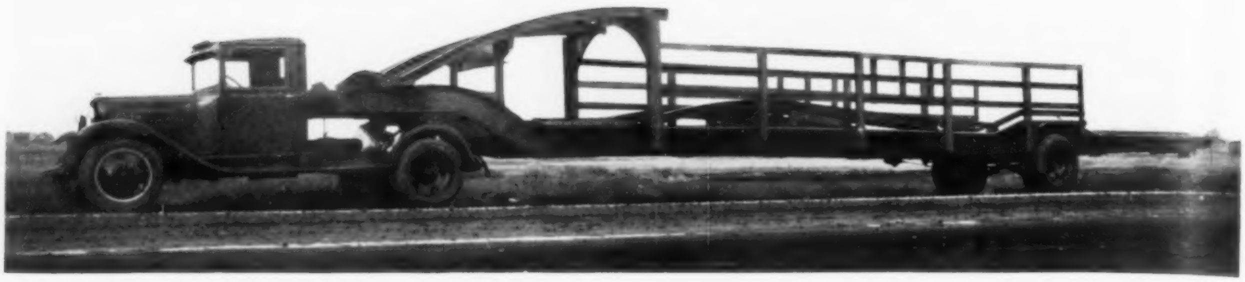
Production on a small scale was again started late in the fall of 1921. Development of larger units could not come until recently, when the market for magnesium had been developed. Individual units in certain stages of our present dehydration process have capacities equivalent to more than 20,000 lb. of metal per day, a year's supply in 1920. Cells of many thousand ampere capacity have been developed and successfully operated. They are certainly worthy descendants of the first 120-amp. cell that produced only one pound of metal in a day.

The use of these large commercial cells has permitted many refinements hardly dreamed possible in the smaller units, such improvements being reflected in a purer, cheaper metal.

A condensed outline of the final process is given in the flow sheet shown on page 34, which is self-explanatory. A battery of electrolytic cells is also photographed. Each one consists of a large rectangular cast steel pot, the lower portion of which is submerged below the operating floor and built into a stoker-fired furnace. The steel pot serves as the cathode and a series of graphite rods forms the anode. Electrolysis is continuous; the cell bath is maintained at the correct level by feeding magnesium chloride through sloping pipes at the front of the cell.

Small globules of magnesium form on the side of the cathode and then rise to the surface of the cell bath where they collect into a coherent mass. Metal is periodically dipped from the cells and cast into ingots, which without further treatment analyse 99.93% magnesium and thus constitute one of our purest commercial metals. Average analyses show the following impurities: Al, 0.022%; Fe, 0.034%; Mn, 0.002%; Si, 0.012%; a total of 0.070%.

The quality of the metal is due primarily to the purity of the cell feed, the absence of ap-



Fifty-Foot Trailer of Strong Magnesium Alloys Saves More Than Half the Weight of an Equivalent Steel Frame

preciable attack of magnesium on the cell parts, and to the washing or purifying action of the cell bath that behaves as a flux to remove possible non-metallic contaminations.

Cost Has Rapidly Decreased

One of the outstanding effects of the growth of the magnesium industry in this country has been the rapid decrease in the cost of the metal. In 1915 ingot magnesium sold for $5 and more per lb. Seventeen years of effort have cut this cost to 30¢ — one seventeenth of the former value. The consumption of domestic magnesium showed several irregularities due to economic conditions. The lower consumption in 1930 and 1931 as compared to the 1929 peak is in the use of magnesium as a scavenger and constituent in other alloys; the consumption of magnesium castings and fabricated articles has remained substantially constant.

The metal magnesium is used commercially in five distinct fields. Pyrotechnics created the first demand and are primarily responsible for starting our United States industry. The memory of the dazzling white light of the photographer's flash has contributed to the prejudice regarding the combustibility of this metal. The most certain proof of this error is furnished by the daily use of magnesium alloys in motor parts and other common applications.

A second important use is the "Grignard reaction" for the synthesis of a wide variety of organic chemicals, especially complex medicinal and perfumery compounds.

Third, the importance of magnesium as a deoxidizer and scavenger is well known, especially to the nickel and nickel alloy industry. About 0.1% magnesium makes these metals sufficiently malleable for mechanical working.

In the fourth place, magnesium is an essential constituent of many alloy systems, particularly those of aluminum and zinc. It is used in amounts ranging from 0.25 to 2% in most of the high-strength aluminum alloys, both cast and wrought, especially those whose properties are improved by heat treatment. It is a small but very important factor in zinc die-casting alloys. Approximately 0.1% exerts a pronounced beneficial influence on their stability, particularly in hot, humid atmospheres.

The important developments of today and tomorrow lie in the utilization of the ultra-light magnesium alloys as *(Continued on page 84)*

RANGE OF PROPERTIES OF MAGNESIUM ALLOYS

Alloy	Condition	Nominal Analysis			Tensile Properties			Brinell Hardness
		Magnesium	Aluminum	Manganese	Ultimate Strength	Yield Point	Elongation in 2 In.	
Magnesium	Cast	99.9			17,000 to 21,000	2,000 to 3,000	8 to 12	32 to 36
Dowmetal E	Cast	93.7	6.0	0.3	28,000 to 31,000	7,000 to 8,000	9 to 12	46 to 50
Dowmetal A	Cast and heat treated	91.8	8.0	0.2	31,000 to 35,000	8,000 to 10,000	9 to 12	48 to 52
Dowmetal G	Cast and heat treated				33,000 to 38,000	17,000 to 20,000	1 to 3	70 to 80
Magnesium	Extruded	99.9			27,000 to 30,000	10,000 to 12,000	6 to 9	35 to 38
Dowmetal F	Extruded	95.7	4.0	0.3	37,000 to 41,000	26,000 to 30,000	12 to 16	45 to 50
Dowmetal A	Extruded	91.8	8.0	0.2	42,000 to 48,000	28,000 to 32,000	8 to 12	54 to 58

Controlled Atmospheres for Annealing and Welding

By J. F. T. BERLINER
Chemical Department
Du Pont Ammonia Corp.
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. . . MANY FUNDAMENTAL metallurgical operations, ever since the beginning of the art, have been conducted in controlled atmospheres, even though the smelter man did not realize it. His mixture of hot ore and fuel, with the air blast working up through it, forms an almost ideal combination for producing automatically the correct balance of carbon oxides, hydrogen, and nitrogen for reducing the ores to metal. In fact, when the innovator attempts to get similar results by artificially mixed gases, he immediately enters a difficult, complex field of physical chemistry.

Steel treaters have known this for a long time. A man's skill may frequently be measured by his ability to heat a metal tool in an open furnace without covering it with deep scale. He often turns to time-honored methods of controlling the atmosphere by pack-hardening and box-annealing, or excluding the atmosphere by using a lead bath; these are too familiar for more than casual mention.

Recent developments in auxiliary processes (such as the continuous sheet mill) and more rigid demands of consumers (such as for equiaxed structure in copper tubing) have required a corresponding advance in the heat treating art, and many of these efforts have succeeded or failed due to the ability or inability of the men in charge to create a proper gaseous atmosphere in commercial furnaces. Many operations of brazing, welding, and the working and treating of rarer metals also need an economical source of pure gas under easy control.

Most of such operations demand either an inert atmosphere or a reducing atmosphere. The first is readily produced by pure nitrogen. Hydrogen is a good example of the second. Mixtures of the two give various steps between the two extremes. It has only remained for the chemical engineering fraternity to produce a handy source of these two gases.

Hydrogen and nitrogen have been available for some years, highly compressed in steel cylinders. One common source of hydrogen was from the electrolysis of water; the nitrogen is a by-product of liquid-air oxygen plants. Ammonia is now a competitive source.

That ammonia, NH_3, can be readily dissociated or cracked into its constituent elements has long been known. Full realization of the commercial possibilities of ammonia as a source of hydrogen and nitrogen is, however, a recent development, and is due to the abundant supply of anhydrous ammonia produced at low cost from the synthesized chemical.

When ammonia is passed over a heated catalyst of suitable character, it is dissociated or cracked into a gas mixture containing 75% hydrogen and 25% nitrogen by volume. Since synthetic anhydrous ammonia of extreme purity is readily available, the product of dissociation can contain only nitrogen and hydrogen in the above proportions, and is therefore superior in purity to gases ordinarily available from other commercial sources.

Compact Equipment for the Automatic Dissociation of Liquid Anhydrous Ammonia Into Mixed Hydrogen and Nitrogen Gases

The portable equipment for dissociating ammonia, developed by the Chemical Department of the DuPont Ammonia Corp., is inexpensive and operates in an automatic manner at low cost. No special technique or training is required for its operation and maintenance. A dissociator, such as the one illustrated, which can produce up to 400 cu.ft. of gas per hr., is only 3 ft. high and 14 in. diameter.

Those who desire a fuller discussion of the equipment may refer to a paper presented by the present author and an associate before the American Institute of Chemical Engineers, Dec. 1930. For present purposes, perhaps the diagram on page 41 will suffice.

Liquid ammonia from the cylinder *A* enters the vaporizer *L* through a flexible connection. Here it evaporates and passes as the gas NH_3 past the safety valve *F*, gate valve *G*, and pressure reducer *H* (similar to the regulators used on cylinders of welding gases) into the dissociator *I*. This is a properly insulated vessel containing the catalyzer and heating coils *P,P*, regulated by thermostat *O*, and the necessary switches and contractors on the board *S*. *V* is a thermocouple well, so the operator always knows the inside temperature.

Dissociated ammonia is led away by pipe *J* through a coil in the vaporizer, wherein it is cooled and exits through *N* to ultimate use.

Contents of one standard cylinder, 100 lb., yield on dissociation 4500 cu.ft. of gas containing 3400 cu.ft. of pure hydrogen. This volume is equivalent to that contained in seventeen standard cylinders of compressed hydrogen. If pure nitrogen is desired, the dissociated ammonia is burned in a closed combustion furnace with the required amount of air. Dissociated and burned ammonia yields 7800 cu.ft. of nitrogen from one 100-lb. container, the equivalent of the content of 39 cylinders of compressed nitrogen gas.

Dissociated ammonia costs but little more than the cost of the ammonia consumed. The cost of the dissociator itself and the auxiliary control equipment is moderate, being of the order of $600. Practically no maintenance, other than occasional change of catalyst, is required, the operation being quite without hazard and virtually automatic. The catalyst itself is a special form of activated iron.

It might appear that it would be impossible to produce pure nitrogen and hydrogen, combine them into ammonia at the expenditure of much energy, ship the ammonia, and dissociate it back into its elements at a cost which could compete with the raw materials. Obviously, it could not be done if every user of these gases could secure them at as favorable a cost as they are produced by the ammonia manufacturer. This cannot be done.

It has been found that the cheapest overall cost of vending the pure gases to consumers of small quantities is in steel cylinders. Even though the gases are highly compressed, the amount contained is only a fraction of the amount locked up in a corresponding volume of liquid ammonia. The cost of the high pressure cylinder, the freight and handling of the

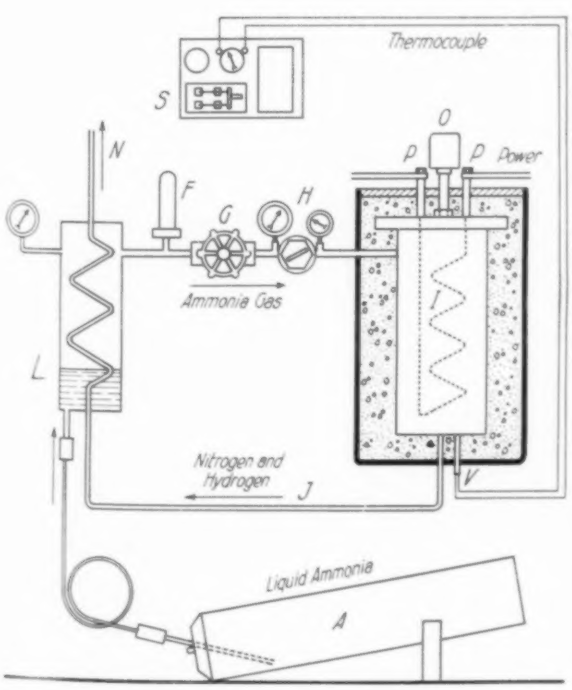
loaded and unloaded cylinder thus absorb the differential in cost between pure gases and ammonia made from them.

Final cost of dissociated ammonia will depend almost entirely on the initial cost of the ammonia laid down in the user's plant, since the dissociator is cheap and easily operated. At present the average delivered price of ammonia in cylinders is about 16c per pound (6c in tank car lots). The overall cost of the mixed gases, inclusive of ammonia, amortization, labor, power, repairs, catalyst, and insurance is about 0.375c per cu.ft. when ammonia is 16c per lb., and 0.155c per cu.ft. when ammonia is 6c per lb.

Burning this gas completely to nitrogen results in a cost of 0.225c and 0.095c per cu.ft. of nitrogen, respectively. Mixtures of hydrogen and nitrogen with a nitrogen content higher than 25% by volume, obtained through partial combustion of dissociated ammonia, may be obtained at intermediate costs. For most metallurgical operations a hydrogen-nitrogen mixture is more desirable than hydrogen alone.

The metallurgical art offers many opportunities for the use of this equipment and gas. To be specific: One of the most interesting operations is bright annealing in the ferrous

Diagrammatic Arrangement of Ammonia Cracking Unit



and non-ferrous industries. Such a process will eliminate the scale and hence the necessity for sand blasting, buffing, or pickling. Bright annealing requires the proper atmosphere both during annealing itself and during cooling to a temperature at which the metal would oxidize or discolor in contact with air.

Compositions of the protective atmosphere that may be employed vary with the metal and the required temperature, but it appears that for most purposes it should contain substantial amounts of inert nitrogen. Whether hydrogen is essential will depend in part upon whether the metal to be annealed has any scale or oxide on its surface, remaining from previous manipulations.

Annealing in an atmosphere containing hydrogen will in most instances remove scale. Furthermore, it will prevent the formation of almost imperceptible films on the surface of the metal. The resultant product has an untarnished surface. Some high carbon steels decarburize slightly when annealed in hydrogen; some chromium steels develop greenish surface oxide which will not be removed by a hydrogen atmosphere; and some alloys of copper become slightly discolored even in the presence of hydrogen. The severity of discoloration apparently is dependent on the temperature, flow of gas in furnace, and purity of gas. In the present state of the art each application is a study in itself.

It is well known that hydrogen acts as a flux to copper on many metals. In its presence, molten copper has an unusual tendency to flow even into the narrowest cracks and joints. This property was first applied commercially to attach tungsten contact points to automobile coils and vibrators. Elaborate continuous furnaces have been devised to copper-braze sheet steel assemblages and render them vacuum-tight by impregnating the metal "pores" and sealing welded joints and crevices between component stampings with hydrogen-fluxed copper.

Copper and silver "brazing" in hydrogen is being done on a large scale, effecting many appreciable economies in operation and producing intricate joints which could be united only with difficulty, if at all, by other means. H. M. Webber has cited many instances of this in a

paper entitled "Copper Brazing in Hydrogen Electric Furnaces," read before the Chicago Convention, A.S.S.T., 1930.

An interesting application of this general relationship of hydrogen and copper has been made by the General Electric Co. It was found that highly compressed and sintered powders, such as tungsten, would absorb a large proportion of molten copper in the presence of hydrogen or hydrogen-containing gases, to produce a material having the electrical and thermal conductivity of copper combined with the hardness and infusibility of tungsten. Utility of such a composite metal for such things as resistance welding electrodes and contactor points is obvious.

Dissociated ammonia is entirely suitable for such atmospheres and has some technical as well as economic advantage over pure hydrogen.

Many applications have been found for copper brazing, such as in attaching tungsten carbide points to steel tool shanks, and turbine vanes to rotors, in making steel tubing and automobile parts, in assembling heat interchangers, golf club shafts, and electrical refrigerator parts such as hermetical seals on motors, floats, and oil check valves.

It has been shown that the copper joint thus formed has about twice the tensile strength of annealed copper.

Dissociated ammonia is also quite applicable to four types of welding; namely, atomic arc welding, shielded arc welding, gas welding, and lead burning.

In the atomic arc or atomic hydrogen welding process, dissociated ammonia is a much cheaper fuel than hydrogen. Furthermore, when pure hydrogen is employed, the area heated by the envelope of burning gas is comparatively large, thus heating a considerable area of metal along the joint and tending to warp the assemblage, especially if made of thin stock. Dissociated ammonia produces a more localized flame and minimizes this defect. On the other hand, the tungsten consumption appears to be slightly higher with dissociated ammonia. Also the welding speed has been reported by some operators to be slightly lower than with hydrogen.

Shielded arc welding is the second variety of welding worthy of attention. In order to avoid one defect of the ordinary low voltage arc — its tendency to form and include oxides and nitrides — the "gas shielded" arc has been developed. The idea is to envelop the electric arc with non-oxidizing or reducing gas. Numerous gases have been suggested; among them hydrogen and hydrogen-nitrogen mixtures are well suited.

Originally it was surmised that if welds were made in hydrogen to the exclusion of carbon, oxygen, and nitrogen, the welds would be more ductile, since they would contain less carbide, oxides, and nitrides. This expected result was obtained but in the course of experiments it was found that a mixture containing a relatively high concentration of nitrogen; namely, 75%, was quite as good as 100% hydrogen, as far as the ductility of the metal was concerned, and the welding arc was even more stable and required less voltage to hold it. Thus the fact developed that nitrogen, instead of being harmful, was, even in fairly high concentrations, entirely permissible and even desirable.

An oxy-hydrogen flame is preferred for a number of welding operations requiring a strongly reducing atmosphere or where carbon deposits or carbonaceous gases must be avoided. Here again dissociated ammonia may advantageously replace hydrogen.

Due to the relatively low heat capacity of nitrogen, it does not reduce the temperature of the flame as much as might be expected. In fact, the maximum temperature of a dissociated ammonia flame in oxygen is theoretically only about 150 to 200° C. lower than that of the hydrogen flame, burning in compressed air.

Mixed hydrogen and nitrogen has been found to be especially adapted to aluminum welding. Work done by W. M. Dunlap in the Aluminum Co. of America's research laboratories reveals that thinner aluminum sheets may be welded with a flame of dissociated ammonia and oxygen than with the oxy-hydrogen torch; 0.012 in. in comparison with 0.028 in.

Comparative physical tests on welds of aluminum made with hydrogen and with dissociated ammonia yielded identical results. Metallographic examination revealed no differences; all the welds were quite satisfactory as regards penetration and no nitrides or other foreign inclusions were present. It was ob-

served that the average speed of welding was the same in both sets of experiments; however, in some tests by another group somewhat better rates of welding were reported for the oxy-hydrogen flame.

Lead "burning" is a type of gas welding for which the oxy-hydrogen torch has been ordinarily favored. Recent tests conducted with dissociated ammonia indicate certain advantages, notably that there is less danger of the unskilled operator "losing the drop and burning through." In seams on large work there also appears to be a definite decrease in warpage of the lead sheet. The actual character and strength of the joints appear to be identical.

A great variety of fuel gases has been marketed for substitutes for acetylene in the cutting blowpipe. It should be noted that although the functions of the preheating flame and the oxygen jet of the cutting blowpipe must be synchronized, they are distinct and separate. The fuel flame preheats the metal to the ignition point, and the subsequent combustion of the metal in the oxygen stream makes the process more or less self-sustaining. Therefore, after the cut is started the importance of the preheating flame is materially reduced. For this reason many fuel gases of less calorific intensity than acetylene have found favor under certain economic conditions. Experiments with dissociated ammonia as a cutting fuel have shown that it is definitely adaptable.

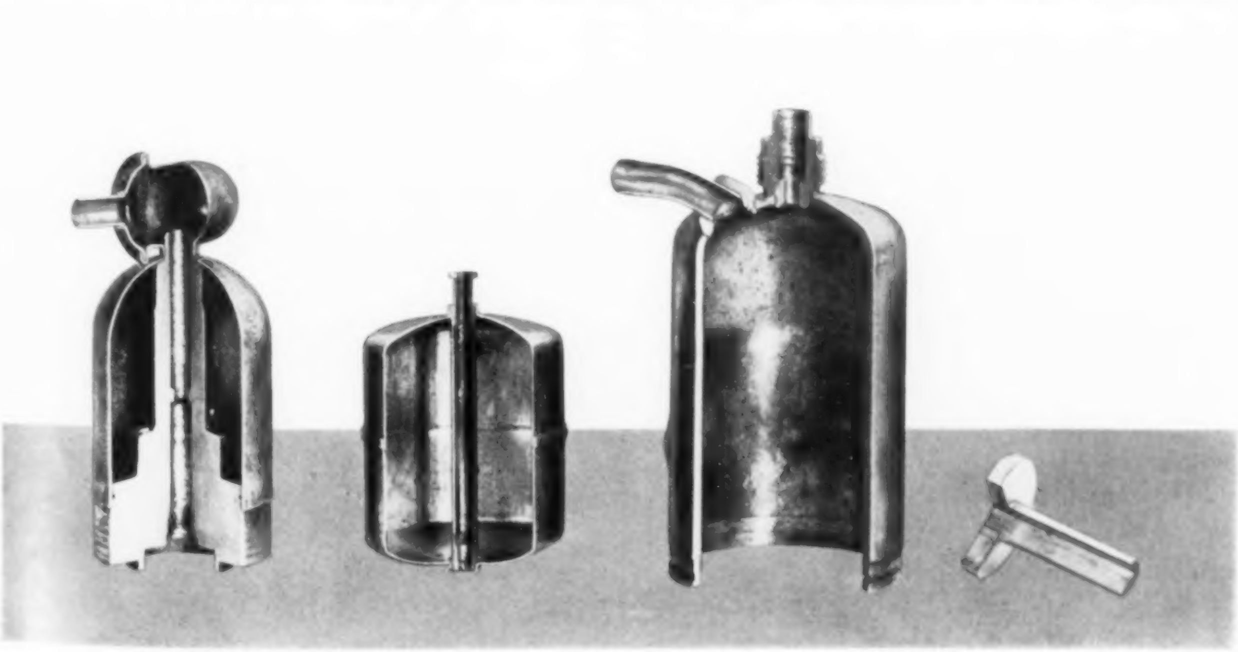
Dissociated ammonia has found considerable commercial application in the production and fabrication of tungsten and molybdenum.

Oxides of these metals are being purified and reduced and the resulting metal powder compressed, swaged, annealed, and drawn in an atmosphere of this gas. There are indications that molybdenum and tungsten wires, annealed in mixed hydrogen and nitrogen atmosphere, have higher tensile strength than when annealed in pure hydrogen, for some unknown reason. High and low temperature annealing of all types of wire is being successfully accomplished with dissociated ammonia.

Cracked ammonia is also being employed in increasing volume for the manufacture of radio, photo-electric, neon and X-ray tubes. The gas is utilized in those steps involving atomic and electric spot welding, bright annealing, and "forming."

The dissociated ammonia flame is admirably suited to melt platinum, as it contains no deleterious carbon or carbon compounds, and it is suitable for the annealing and "burning" of platinum and platinum alloys.

Cutaway Sections of General Electric Refrigerator Parts, Copper Brazed in Hydrogen Atmosphere. All joints in each assembly made simultaneously and automatically



Forming Annealing & Polishing Utensils of 18-8

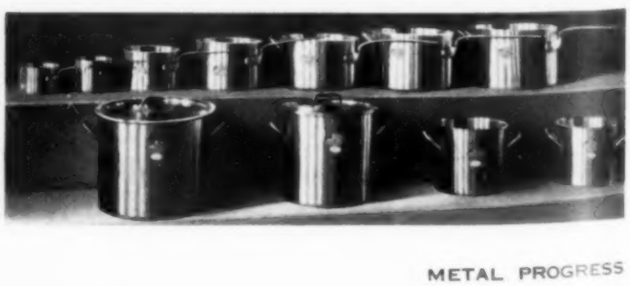
As told by foremen
at Lalance & Grosjean
Woodhaven, N. Y.

. . IT IS ONLY NATURAL THAT progressive manufacturers of sheet metal ware should study the possibilities of the new corrosion-resistant alloys. If the firm has been established for a span of years, it has seen many styles in utensils wax and wane, will appreciate the selling power of novelty, and will be able to fix upon the outlets where the non-staining qualities of high chromium-nickel steels are sufficiently appreciated to warrant paying the considerable premium which must be charged to cover the more expensive raw materials.

Hence it is that Lalance & Grosjean Mfg. Co., having a well-equipped plant at Woodhaven, N. Y., where galvanized, enameled, and bare utensils of iron, copper, and other sheet metals had been made for many years, introduced some new lines made of Allegheny metal, a low carbon, 18% chromium, 8% nickel alloy. (It is generally agreed that 18-8, of all the commercial "stainless" alloys commonly marketed, has excellent all-around corrosion-resisting properties and, in the low carbons, is ductile enough for severe cold work. Such reasons are responsible for its widening popularity in the food handling industries, and for chemical equipment, for decorative objects, or architectural trim.)

On working with corrosion-resisting steel sheet, it was quickly found that existing equipment in heat treating, pickling, spinning and polishing departments, installed to handle steel and copper sheet, was adaptable to 18-8 after certain changes had been made. However, the presses were generally incapable of forming stainless utensils in equal sizes and thicknesses. Approximately three times as much power seems to be required for an equivalent draw. Put in another way, the largest press in the old line was capable of making a 100-qt. stock pot of 14-gage steel sheet in nine draws. The best it could do in seven draws on Allegheny metal was the 36-qt. pot of 16-gage metal. (Sizes are 19 in. diameter by $21\frac{3}{4}$ in. deep and 14 in. diameter by $15\frac{1}{2}$ in. deep respectively.) What is thought to be the largest and heaviest deep drawing press in America was thereupon installed at Woodhaven to make these pots and to form other large pieces, such as 10-gal. milk cans, 13 in. diameter and 23 in. deep.

Given a powerful press capable of exerting 1200 tons at bottom of the stroke, the rest of the drawing technique is easy. No change was made in the lubricant from the material used for heavy steel sheet. Clearances on dies are the



same — in fact, a given set of dies can operate interchangeably on deep drawing steel sheet or 18-8. Machine speeds are the same. Wear on dies (especially blanking dies) is more severe.

Anneal After Each Draw

Deep drawing, as of a milk can, could be conducted in a greater number of steps on lighter machines, were it not for the fact that austenitic alloys like 18-8 harden rapidly on cold work, and must be heat treated after each draw. Furthermore, heat treatment should follow promptly after cold work — a large percentage of parts left over night will be found cracked from internal stress by next morning. Economical production therefore requires a minimum of press operations, each followed by an anneal.

Two continuous annealing furnaces, oil fired, are available in the Woodhaven plant. One has a conveyor hearth, the other rails of heat resistant alloy. Hearth dimensions are 60 in. wide, 54 in. high, and 15 ft. long. Operating temperature is about 1950° F., a heat high enough to relieve internal stress and redissolve any liberated carbide almost immediately. For this reason the time of transit of an article made of 16-gage sheet is only about 5 min. Hot articles withdrawn from the furnace are stacked on the floor for air cooling.

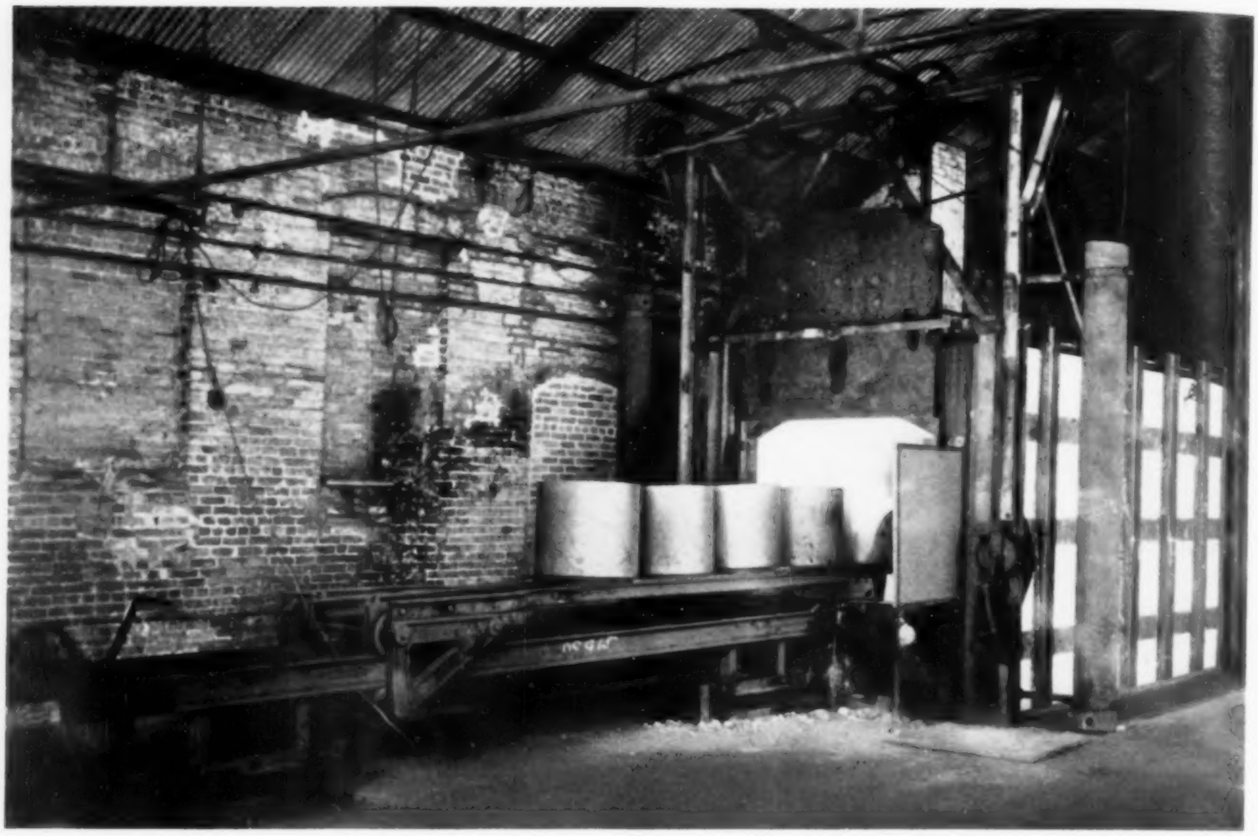
Such treatment in an open muffle furnace, of course, ruins the mill finish; the partly formed article has a closely adhering scale, but this does not interfere with the subsequent press operation. When the final draw and anneal have been performed, it is time to remove this mill scale.

Pickling is done in a series of four tanks. In the first is boiling 10% hydrochloric acid. It takes 35 to 40 min. immersion to loosen the most of the oxide. After rinsing in water, the parts are placed in lukewarm 10% nitric acid for 12 to 15 min. to bite into any final adhering particles; it does not attack the metal to any appreciable extent. Another warm water dip removes the acid, but the surface is still covered by a powdery black deposit. This is removed by hand scrubbing; a damp sponge, loaded with fine, white beach sand, is the best implement to use. Another wash and the part is ready for spinning and trimming, or if the shape is correct, for polishing.

All Articles Spun and Polished

Stainless steel sheet in various gages from 14 to 24 is delivered to Lalance & Grosjean from the mill with a 180 to 200 finish. That is, the hot rolled and heat treated sheet has been pickled, given a light reduction cold, and then ground with a succession of grease wheels with finer and finer grit, down to 200 mesh. This finish is by no means a mirror-like polish, but the surface markings are sufficiently fine for satisfactory and attractive utensils. Unfortunately, few

1200-Ton Press Installed for Deep Stock Pots and Milk Cans, Since Spontaneous Hardening of Austenitic Alloys Absorbs More Power Than Carbon Steel



Formed Articles of 18-8 Sheet Are Annealed at 1950° F. After Each Press Operation. Five minutes at this heat is all that is required, but the heat treatment should be done shortly after cold working in order to prevent cracking from internal stress

articles can be formed from the flat sheet without requiring a stress-relieving anneal — an example would be a fry pan, with sloping edges turned up at about 15° for an inch or so. Operations for such a piece would be: Blank, press, wash off lubricant with gasoline, dip in nitric acid tank to remove traces of steel on abraded areas, wash, spin, trim, affix handle, wash, hand rub, and inspect.

Even though it is unnecessary to remove scale before a second draw, it must be done before spinning a deep drawn utensil to final shape, else the scale would be pressed into the metal and form a pitted surface requiring an excessive amount of rough grinding. Each round article is spun after pressing, even if the shape is not changed, in order to smooth out wrinkles.

If the piece is merely smoothed in this operation, it passes on to the polishing department. If much work is done, as necking in a pitcher or flask, the piece is again annealed and pickled. Owing to the stiffness of the stainless metal, a workman can produce hardly one-quarter the number of pieces he could if spinning the same gage of deep drawing steel stock.

Polishing Is Slow

Polishing is an even slower operation. The 18-8 analysis, being an austenitic alloy, has certain similarities to high manganese steel, since it spontaneously hardens as it is worked or cut. Polishing wheels should work at high speed, and the piece becomes heated by friction to the boiling point of water or even hotter. The workman's skill consists of holding the piece against the wheel with the proper force, and still permitting it to roll slowly in his heavily mittened hands, so the entire inner or outer surface is traversed at uniform speed by the grinding wheel.

Muslin wheels of 5 to 16 in. diameter are used, the size varying as the diameter of the piece polished. Wheels once used for 18-8 are reserved for this purpose exclusively. Spindles run at 2200 to 2500 r.p.m. First grinding is done

with a wheel loaded with 60-mesh grit; next step is with No. 120, and last with No. 200. This gives a polish somewhat smoother than the sheet as delivered from the mill, and, as remarked above, quite sufficient for dairy, restaurant, or hotel kitchenware.

Extra Steps for High Polish

Some items, such as pitchers and small articles for hospital use or for housewives, have this 200 finish inside, but have a highly polished exterior, requiring two extra steps, a buff with tripoli and final polish with green rouge.

Handles are seamless tubing of the same analysis, bent to shape and ends flattened for rivets (also of 18-8). After such minor matters are attended to, the articles are washed in hot, soapy water, given a final vigorous hand rub with a talc-covered cloth, and are then ready for inspection and wrapping.

Principal outlets for utensils made of 18-8 alloy have so far been to the kitchens of hospitals, hotels, and restaurants. The clear, lustrous finish is very attractive, and will remain so indefinitely with no more than the ordinary care demanded by cleanly habits. Gage of the original sheet is in keeping with the size of the article, so the ware gives an impression of sturdiness and durability. A great deal of this ware is being purchased by hospitals on account of its permanent resistance to drugs, disinfectants, and organic substances. Similar resistance to lactic acid, and other decomposition products of milk, gives stainless utensils definite advantages to the dairying industry, which wide-awake men in that line are regarding as well worth the increased cost over tinned ware and bare steel.

While an attractive line of small kitchen utensils has been put on the market, few housewives are now willing to pay two or three times the cost of enameled or aluminum ware for the stainless article. That is a promotional job for the manufacturers of stainless steel utensils to work up in the future.

After Heat Scale Is Removed and Article Smoothed by Spinning, It Is Polished Inside and Out on Muslin Wheels Loaded With 60, 120, and 200-Mesh Grit Respectively. Highly reflecting surfaces are produced by two extra operations, a buff with triopli and next a polish with green rouge

Transportation Building, World's Fair, 1933

Photo by Rittase

Editorial

LINDBERGH, by flying the ocean alone, and by his modest demeanor under fulsome praise, became the national hero and the ideal of clean American youth. Within a few years he has done important work in the business of commercial aviation, and this embryonic giant of industry owes him much. We now look for him to devote several years of his vigorous life to the extermination of kidnapping gangs — in which effort he will be backed to the limit by every right-thinking citizen. On the completion of this great and sadly neglected work, he will have earned the gratitude of his country, and will have achieved a firmer basis of fame by reawakening the national consciousness as to right and wrong.

MORE and more metal is being used for decorative purposes. Architects are turning to metal and glass as the best constructional materials for the exterior walls of buildings; interior decorators are equally successful with the new mediums. This trend in design will get a pronounced fillip from the Chicago Exposition next year; its architects are achieving startling effects with vivid color and bright metal. No one can remain indifferent to these ultramodern buildings; the visitor either damns them or hails the dawn of a new era. It is reasonably safe to predict that the latter contingent will be quite numerous and influential, and the next decade will witness the erection of many unconventional structures, like the one opposite, largely decorated with metal.

In this respect, history will be merely repeating itself; Philadelphia's Centennial Exposition in 1876 and Chicago's Columbian Exposition of 1893 set the style in buildings and decoration for a generation. Times are ripe for a change.

Undoubtedly some awful atrocities will be achieved. Also some disappointments await the architect, decorator, and owner who will find that the metal, for some reason or other, fails to fulfill the seller's promises. How to avoid these failures will merit some study. It is too much to expect that the great consuming public will become expert and discriminating metallurgists. Manufacturers and sellers of the tarnish-resisting alloys should therefore be chary in their recommendations, and make every effort to insure that the metal chosen has the best possible chance to perform satisfactorily. Some expensive and glaring failures (as of the so-called chromium plate on automobile hardware) would give a valuable material a bad name requiring years to live down.

Since tarnishing is a surface effect, it really is remarkable that some producers of bright metals scant the work done on polishing and cleaning that surface. Yet it makes all the difference in the world in the permanence of the exterior finish.

An architect recently told of the selling tactics of a hardware house which claimed that the butts and other door hardware submitted by it for a certain large building "had the heaviest nickel plate of all the competing materials," a claim which investigation justified. But when random samples were left in dilute uric acid (a pretty good test for metal coming in contact with humans), the heavy nickel plate failed among the first, and the last to go was from one maker with an established reputation for excellent goods, yet which was covered by a relatively thin plate. Undoubtedly the main reason for its superiority was that this durable ware was highly polished and scrupulously cleaned both before and after the electroplate was deposited.

Editorial

This matter of smoothness has a controlling influence on the retention of bright surfaces in smoky, populous centers. Shiny metal pilasters are placed on a building. How long will they stay clean? Each microscopic pit offers lodgment for even smaller particles of dirt. These, being below the average surface, are protected from the blasting wind and rain, and even though the surface underneath may be entirely unchanged, the lustrous appearance is dulled. It is clear, therefore, that the amount of washing required to maintain the appearance of a non-tarnishing metal will depend upon its surface smoothness, and the absence of joints and crevices where dirt-fall accumulates.

Some metals seem to repel or dislodge dirt automatically. Everyone has seen the green patina acquired by bare copper roofs, cornices, and downspouts — a green that persists even though the supporting walls are coal black with grime. Gold leaf has a somewhat similar property. Its use for exterior decoration is limited by its cost, but in at least one important building it has served where other things failed.

This is the American Radiator Co. building in New York, facing Bryant Park at the rear of the Public Library. The architect used black brick for the skyscraper, but the trim at the towering top was to be bright yellow — a huge pile of coal burning with flame. Night illumination was to enhance the striking effect.

Top trim was built of yellow-colored terra cotta, but this was smoke streaked before the structure was inhabited, and steadily approached the color of the masonry below. Obviously, the desired effect was lacking and experiments were tried with brass sheathing, brassy-colored lacquers, and aluminum paint. None of them retained their shine, and finally the whole top (several thousand square feet) was covered with gold leaf.

After several years this metal retains its shine. The dullness which is now appearing seems to be due to wear! The leaf was stuck close against the terra cotta, and this surface was far from smooth. Each of the billions of tiny protuberances on the tile projected into the elements, a target for swirling rain and wind-blown dust. Eventually the little peaks have been worn quite clear of gold and the lack-luster terra cotta shows through the shiny layer of yellow metal.

So from more than one angle the smoothness, the cleanliness, and the hardness of surfaces are of importance when the metal must retain its original sheen for years. Nothing but the best of metal, processed with most pains-taking care, will serve.

WHEN one of the leading electrical manufacturers withdraws from the household appliance field, because its apparatus cannot meet the prices set by small assembly plants, does it mean that the small organization is putting shoddy material into the devices, just good enough to pass the Underwriters' regulations, or is the difference due to the big organization's advertising, research, and sales promotional expenses? No matter what the answer, the event is bad news for the purchasing public and the intelligent manufacturers of quality metals.

THEY were talking of razor blades. (According to the advertisements, men at their ease always talk of razor blades and shaving soaps!) But they were really discussing razor blades, and these men were men who knew something about steel and its possibilities, and consequently were marveling that there is such a wide variation in quality, blade to blade, in even a single package. For evidently the modern razor blade is a child of mass production, and blade No. 2 was probably cut from a strip of steel just ahead of blade No. 3, and each automatically shaped, ground, hardened, and honed. No. 2 should be indistinguishable from No. 3; each should be good, indifferent, or poor, depending upon what the sum of the operations produced. Yet all those present agreed that no such uniformity exists.

Of course, these metallurgists, not being

connected with the razor blade industry nor having scientific equipment in their bathrooms, were testing the blades against their own beards. Such qualitative and rough-and-ready testing involves some tacit assumptions which certainly are not true, such as (*a*) my beard grows the same length each 24 hr., (*b*) the softening action of the shaving soap and hot water is always the same in amount, (*c*) I manipulate the blade in exactly the same way each time I shave, (*d*) my sensory nerves are uniformly reactive to stimulation, (*e*) my recollection of the conditions experienced during yesterday morning's shave is clear and complete.

Undoubtedly such tests of "shavability" are colored by the personal element of the tester to an unexampled degree. Recognizing this, the opinion was still unanimous that even though the new razor blades in the package might be as like as two pins, they were deficient in the uniform ability to surmount the variables associated with the morning's shave. The first blade might last a week, the second ten days, the third would be thrown away at the second attempt. One wonders what tests the razor makers themselves use to determine this matter of uniformity and high quality, or, in fact, if there can be any physical test which has any relationship to shavability.

The conversation gradually progressed to an experience meeting on how to prolong the usefulness of safety blades. One man emphasized the importance of drying the edge completely. Another doubted whether it was possible, with only a dry towel, to get all moisture out of the tiny cracks in a used edge. A third opined that the only advantage of alloy blades was their superior resistance to corrosion in the hot, humid atmosphere of a bathroom. A fourth said that it was too much to expect a razor to maintain a delicate edge without careful stropping and honing. Another made it a practice to rub a blade back and forth inside a drinking glass to straighten out the cracked and bent-over edge and cold work it slightly.

One spoke with some hesitance: "Did you every try a magnet? Sounds foolish, doesn't it? I feel a good deal like a fakir when I do it, but nevertheless I am sure it works. When I dry the blade, strop it, remove it from the holder, and lay it across the poles of a sizable horseshoe magnet until next morning, I get a much better shave and more of them."

Editorial

Another in that razor-discussing group had heard of a "sharpener" which used a magnet, and remembered wondering who would be gullible enough to buy it. Doubtless many metallurgists were equally skeptical when they first heard that Mr. Herbert in England claimed to be able to superharden steel with a magnet. Everyone will admit, however, that preconceptions have no place in research (even on the effect of magnetism on the shavability of razor blades!) A scientific investigator will record the facts he observes, whether they be the results he expects or the exact opposite. Nor will he disregard the "erratic" tests. His own prejudices must be excluded.

We confess a lively interest in both problems, namely, the shavability of razor blades and the influence of magnetism on hardness. Unfortunately, Metal Progress has been unable to secure as credible an account of the first problem as is Mr. Herbert's article about the second, on the next page. We hope, however, to hear more about both in the future; both are important — possibly they may be interrelated.

THE CYNIC, whose cure for our present depression is a man-sized war, nearly has had his prescription tried in the argument about Shanghai. Reports from Japan indicate, however, that the industrial and financial situation in that tight little country is even more parlous than before the Manchurian adventure started. As to China, probably 90% of the inhabitants do not know that anything out of the ordinary has happened. So the cynic's prescription seems to be defective, at least as far as the combatants are concerned. At the very best (or worst) it is more in the nature of a "shot in the arm" than a curative medicine for the rest of the world.

Hardness Changed by Magnetism

By EDWARD G. HERBERT
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. . IT HAS LONG BEEN RECOGnized that the apparent inertness of metals is illusory and that accurate measurements, carried out over long periods of time, will generally show that changes have occurred. The most familiar instances are the changes in the dimensions of gages and of iron castings. This class of phenomenon has attracted much more attention since the discovery that age hardening is a property common to a great variety of alloys.

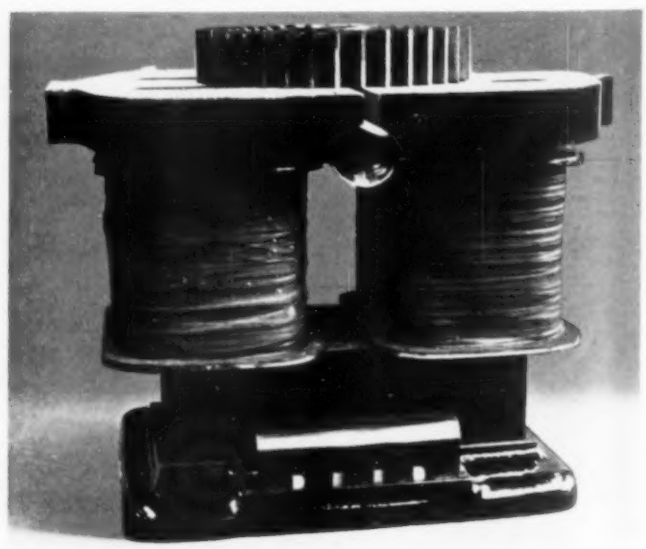
My attention was first directed to this subject by the discovery that steel which has been superhardened by "cloudburst" bombardment with steel balls markedly increases in hardness for several hours. (For a description of this process, see A.S.S.T. *Transactions* for 1928.) The severe mechanical deformation of the steel surface might set up internal strains, and these might relieve themselves during the aging period, but such an explanation seemed quite inadequate to account for a gradual spontaneous increase of hardness. It seemed more probable that this change was due to some rearrangement of the atoms in the space lattice.

Acting on this supposition, the steel, after it had been superhardened and aged to stability, was placed across the gap of an electromagnet and slowly rotated. If the atoms were seeking new positions, they might be assisted by creating a magnetic disturbance among them. A marked increase of hardness occurred.

Then followed a long research to discover the most favorable conditions for such "magnetic hardening," and this eventually led to the discovery that the above-mentioned rotary magnetic treatment set going a progressive change of hardness which was only completed after the lapse of many hours. There were, in fact, two new age hardening phenomena, the first occurring after mechanical deformation, the second after magnetic disturbance.

Attention was then directed to alloys in which age hardening was known, namely, in freshly quenched duralumin and in freshly quenched tool steel. Could the age hardening

Electromagnet Capable of Field Strength of 19,000 Gauss Within the Gap, Used in Experimenting With Duralumin and Other Non-Magnetic Metals in Hardness Determinations



process in these metals be assisted or otherwise affected by magnetism?

As it seemed unlikely that a metal such as duralumin could be affected by a simple magnetic field, recourse was had to the high frequency induction furnace, which would no doubt set up a very violent atomic disturbance in the metal. Specimens of thin duralumin foil were quenched from 930° F. and immediately placed in a glass of cold water and subjected to measured periods of high frequency magnetic treatment. The course of the subsequent age hardening process was then traced by frequent hardness tests, side by side with tests on similar specimens which had been simultaneously quenched but not magnetically treated.

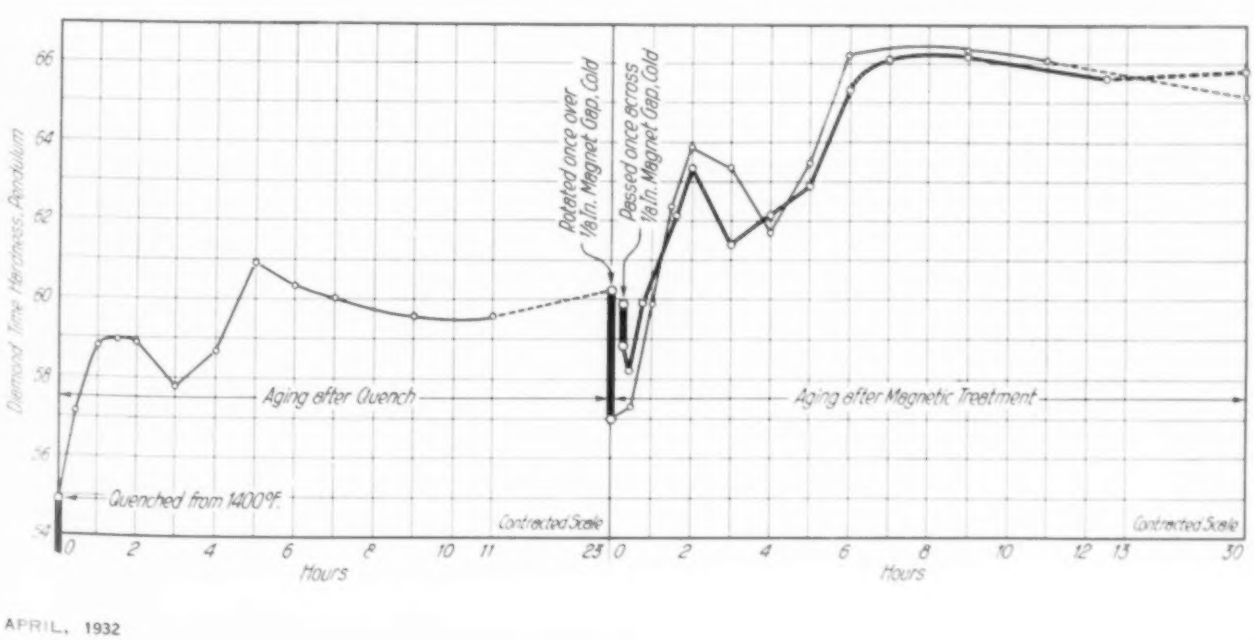
A new phenomenon — "age softening" — now appeared. The duralumin, after only 1 sec. of high frequency treatment, showed first a softening during 8 hr., followed by a greatly delayed age hardening. A longer period of high frequency treatment caused first a softening, then an accelerated age hardening, and a second period of "age softening."

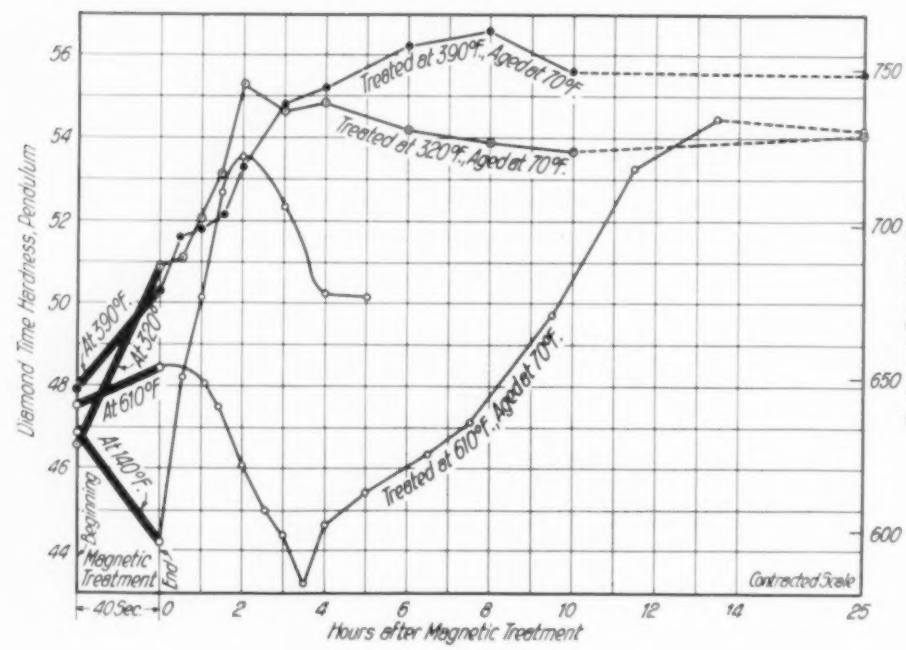
Not less than five tests were made at each period, to eliminate the effect of local variations of hardness, and serial testing was done at intervals of 15 or 30 min. during the early stages and later at hourly intervals. This improved technique soon revealed the fact that the age softening of duralumin was not an isolated phenomenon. Alternating stages of softening and hardening were found to occur in the aging of freshly quenched tool steel, hard and soft steels hardened by "cloudburst," and hard and soft steels, duralumin, and brass, after magnetic treatment.

The graph printed below shows one of a great number of instances. A specimen of plain carbon steel (0.9% carbon) was quenched from 1400° F. Hardness increased to a maximum 1½ hr. after quenching, fell to a minimum at 3 hr., rose to a second maximum at 5 hr., fell slightly, but was apparently stabilized at 23 hr. The same specimen of steel was then subjected to magnetic treatment, namely, a single rotation over the magnet gap in 40 sec., which resulted in a cycle of five alternating hardness changes closely resembling those caused by quenching.

Another specimen similarly quenched and aged was not rotated but merely drawn once across the 1/8-in. magnet gap, and this caused an almost identical cycle of changes. A great number of such experiments proves that a specimen which had gone through its cycle of changes and reached stability could be made to pass through a similar cycle again and again by a repetition of the magnetic treatment, with, however, a general decrease in the amplitude

Fluctuations in Hardness of 0.9% Carbon Steel Immediately After Quenching Are Duplicated at a Higher Level by 40 Sec. Exposure to Magnetic Field of 6200 Gauss. Re-exposure to magnetic field causes a repetition of the hardness changes





Samples Cut From 18% Tungsten High Speed Steel Saw Were Heated to Temperatures Noted and Rotated in Magnetic Field. Resulting hardness changes of pieces at room temperature were noted

of the fluctuations, accompanied by a progressive rise in the hardness level.

(In all experiments my pendulum hardness tester was used. For the benefit of those not familiar with the scale it may be stated that "diamond time hardness" multiplied by 13.5 gives the approximate Brinell hardness number on hard steel. The electromagnet used has cast iron pole pieces and a fixed gap ⅛ in. wide. The strength of the field within the gap is 6200 gauss. The magnetic induction passing through one of the hard high speed steel specimens 0.071 in. thick bridging the gap is 17,000 c.g.s. lines of force per sq.cm.)

Extensive experiments were next made to find the effect of temperature. An aluminum bath containing water, oil, or fused salt was fixed across the magnet gap, and the specimen was rotated by means of a wooden key in the magnetic field at the bottom of the bath. A set of such experiments on specimens cut from a high speed steel saw blade, magnetically treated at 140, 320, 390, and 610° F., respectively, is shown in the diagram on this page. They were aged cold, and hardness fluctuations were found.

It will be readily imagined that there was continuous speculation as to the inner meaning of the newly discovered phenomena. Rearrangement of atoms in the space lattice seemed to be inadequate to explain alternating changes of hardness (following mechanical, thermal, or magnetic dusturbance of the structure) capable of repeating themselves almost without limit. The current explanation of age hardening in the aluminum alloys, based on the precipitation of submicroscopic constituents, was hardly more helpful; it might account for the general increase of hardness, but scarcely for alternate softening and hardening. Moreover, these phenomena had been found to occur in such a variety of metals, that it became necessary to rule out any explanation based on facts appertaining exclusively either to ferrous or to non-ferrous metallurgy.

It was finally concluded that hardness fluctuations (whether produced by mechanical, thermal, or magnetic agency) are due to periodic fluctuations occurring within those elementary electromagnetic structures of which all metals are built — namely, the atoms. Fluctuations of hardness must be regarded as fluctuations in the interatomic attraction or cohesion which is the basis of all the physical properties we know and measure. The actual nature of the fluctuations within the atoms must be a matter of speculation.

This theory, regarded as a provisional working hypothesis, has been found capable of giving useful guidance. Several corollaries follow from it; one for instance:

If the hardness fluctuations are due to oscillations of the elementary magnets of which the metal is made up — the atoms — then it should

be possible by placing the oscillating metal in a strong magnetic field to affect the normal course of the oscillations, and there should then be a corresponding alteration of the hardness fluctuations.

The following experiments were devised to test the validity of this conclusion: A piece of the high speed steel saw used in former experiments was given one turn (40 sec.) in the electromagnetic field at 390° F., aged to a maximum (which occurred at 3 hr., as shown in the third diagram), and then placed for 3 min. in a constant magnetic field. The expected course of the hardness change, shown by the dotted line, was entirely altered. There was an immediate fall in hardness followed by a marked rise to stability above the previous maximum. Another specimen of the same steel was given the same magnetic treatment at 610° F., aged to a minimum, and then "stabilized" in the constant field. The result, shown in the diagram, was a temporary fluctuation followed by a fall to stability *below* the previous minimum hardness.

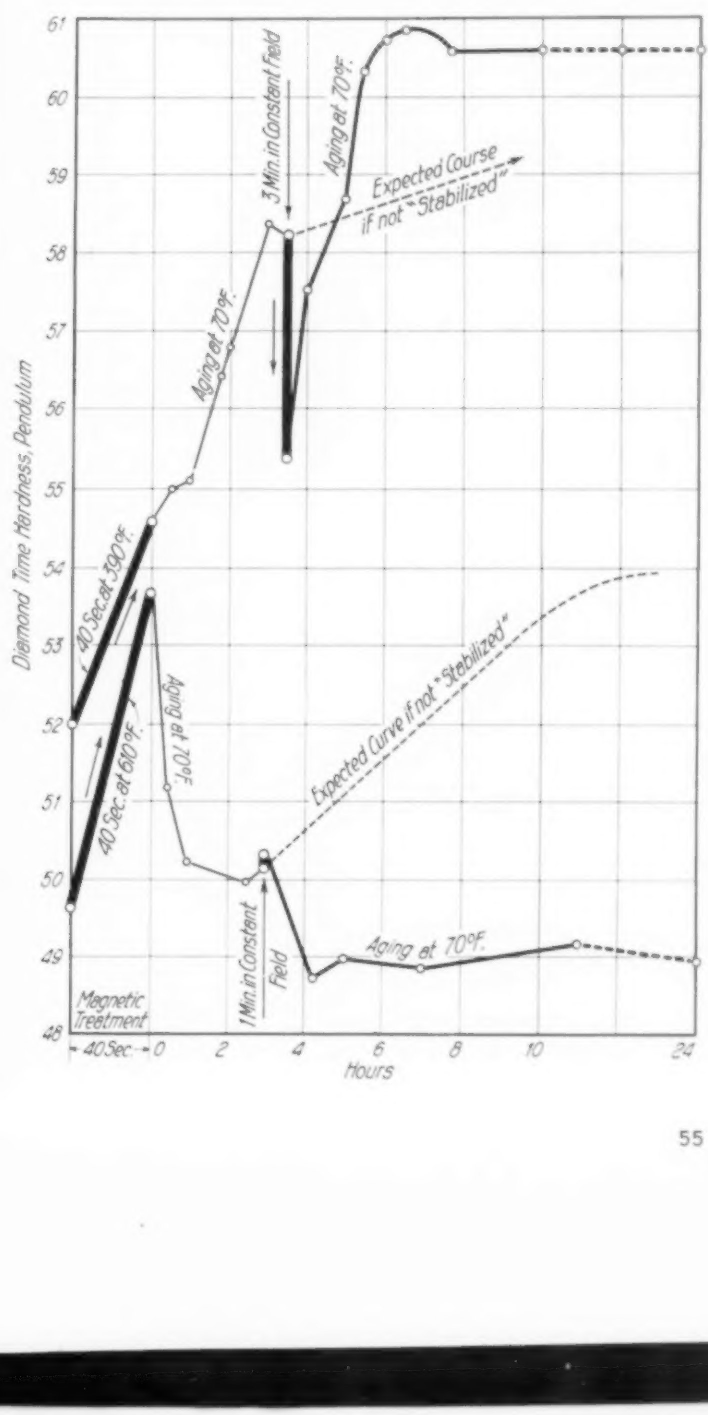
These results are quite characteristic of the effect of stabilizing magnetic treatment on fluctuating steels at maximum and minimum phases. They also confirm the supposition that the hardness fluctuations are really caused by magnetic pulsations capable of being influenced by magnetism.

A second corollary is as follows: If, as the theory requires, the fluctuations set up by mechanical, thermal, or magnetic disturbance of the atomic structure are all electromagnetic in character, the effect of the strong magnetic field on the oscillations should be similar whether they have been started mechanically, thermally, or magnetically.

To check this point, a specimen of 0.76% carbon steel was quenched from 1440° F. and the course of its "quench fluctuations" was traced by hardness tests at short intervals. The hardness rose to a maximum at 1½ hr., and 30 min. later (when it was clear that the maximum had been passed) the specimen was "stabilized" magnetically. The effect was found to be like that of a similar treatment applied to magnetic fluctuations: Namely, a temporary fall followed by a rise to stability above the previous maximum. The conclusion is that the fluctuations set up by quenching are similar to those set up by rotary magnetic treatment.

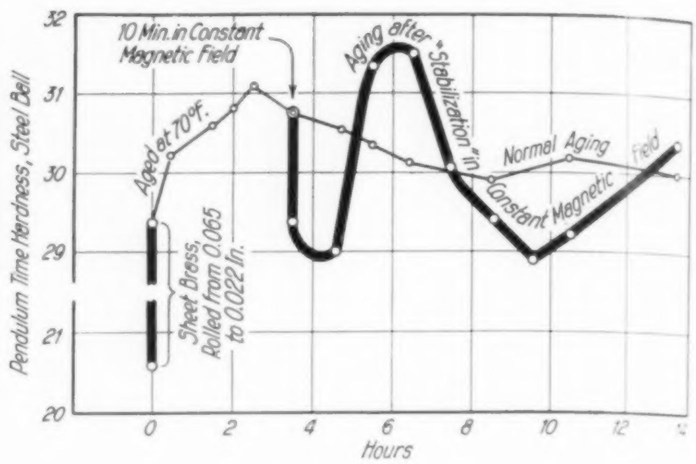
Thirdly, a specimen of sheet brass was put into a "state of oscillation" by rolling from 0.065 to 0.022 in. thick and then serially tested for hardness. The result of this experiment is shown in the last diagram. The hardness rose

Steels Exposed to a Strong Uni-Directional Magnetic Field Just After Passing Maximum or Minimum of Hardness Are Stabilized Quickly at Higher and Lower Levels Respectively



during 2 hr. after the rolling process, and 1 hr. later, the maximum having been passed, the specimen was cut in two. Normal aging of one half was continued, and, as shown by the thin line, resulted in a slow fluctuation to a condition of virtual stability in 14 hr.

The other half of the specimen was "stabilized" by being placed in a strong magnetic field for 10 min. (Although this metal is non-magnetic, the copper and zinc atoms comprising it are nevertheless electromagnetic structures, and should therefore be susceptible to the influence of a strong magnetic field.) The intention was to stabilize the maximum hardness, but the "stabilizing" treatment set up new fluctuations.



Non-Magnetic Metals, Work Hardened and Aged to the Maximum, Endure Rapid Fluctuations in Hardness After Exposure to Strong Constant Field

This experiment has been repeated many times and the result shown is quite characteristic of the effect of a constant magnetic field on non-ferrous metals whose atoms have been set in a state of oscillation by mechanical, by magnetic, or by thermal treatment. Once more the conclusion is irresistible: Fluctuations in non-magnetic metals, like those in steel, are electromagnetic in origin and susceptible of influence by magnetism.

Persistent efforts have been made to stabilize the hardness fluctuations in duralumin and other non-magnetic metals, but so far the conditions necessary have not been found. Experiments are projected employing a much stronger magnet with an adjustable gap and capable of producing a field strength of 19,000 gauss in the open field within the gap.

Recent investigations have indicated that there is a critical range of field strength within which the hardening phenomena occur. Too strong a field causes hardness fluctuations whose range is generally below the original hardness level, and the ultimate effect is not a hardening but a softening of the steel.

When Michael Faraday was asked about the usefulness of his discovery of electromagnetic induction, he is said to have replied, "What use is a baby?" So far as the magnetic treatment of non-ferrous metals is concerned, one can at present only offer a similar reply. The discovery is of so fundamental a character that it must almost inevitably lead to important developments in theory and practice, but the nature of these developments cannot be foreseen.

The possibilities of magnetic treatment of hard and soft steels are somewhat more apparent. Hard steel depends for its utility on its hardness, and in general, an increase of hardness, if unaccompanied by brittleness, increases its utility. The rotary magnetic process has been found capable of effecting a considerable increase of hardness in every variety of hard steel to which it has been applied, while the secondary or stabilizing process further increases the hardness and renders it permanent. All the evidence so far available indicates that this increase of hardness does not embrittle but rather toughens the steel. In this respect the effect resembles that of the secondary heat treatment commonly applied to high speed steel; it increases the hardness but toughens even more than it hardens.

Usefulness of magnetic treatment to unhardened steels is likely to be of a different character. Soft steel can be readily put into a state of fluctuation by rotary magnetic treatment, and its hardness can be increased, but the increase is scarcely such as to be useful in itself. It has been found, however, that when an unhardened steel is passing through a minimum phase of its hardness fluctuations it is in a specially ductile condition, and that this condition can be rendered permanent by a stabilizing process. The possibilities held out by these experimental facts are sufficiently obvious.

Test for Smoothness of Machined Surfaces

By F. A. FIRESTONE
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. . . IT IS OFTEN DESIRABLE TO measure the roughness of a machined surface and to determine the nature of the irregularities when studying the machinability of metals or the noise produced by gears and similar mechanisms. An instrument for this purpose was developed by the writers in the course of some work at the Department of Engineering Research, University of Michigan, sponsored by Timken Steel & Tube Co.

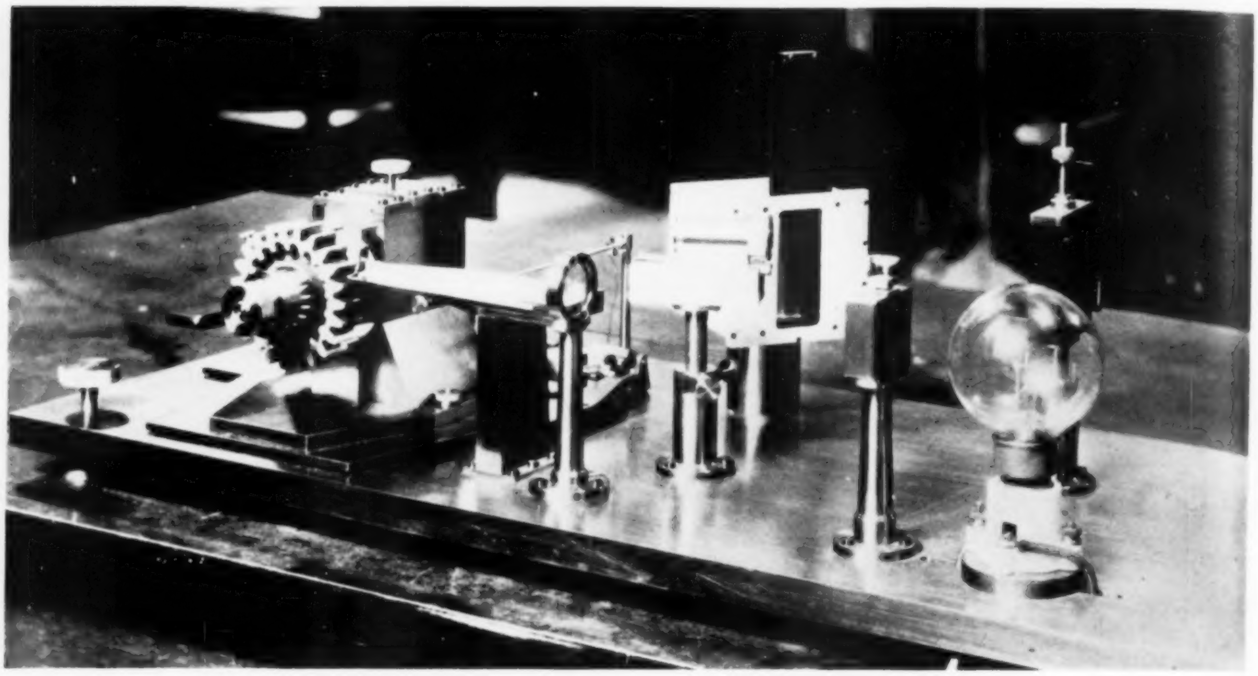
Its fundamental principle is very simple. The surface to be measured is traversed with a fine tracer point connected with a small mirror so that the movements of the tracer produce angular displacements of the mirror. Displacements of the mirror are then recorded by a spot of light on moving photographic paper.

The essential features of this instrument are illustrated in the half-tone and the drawing of the arm (which appears just to the right of the gear in the photograph). The arm is supported on the right by an elastic hinge *H*, and on the left by the pilot point, a small screw with a slightly rounded point. This point rests on the pilot surface, which is a smooth surface of the same nominal curvature as the specimen to be measured. A small block *b* is mounted on the end of the arm by means of a smaller elastic hinge *h*. This block carries the tracer point and the mirror. The pilot point and the small hinge *h* are the same distance from the large hinge *H*. A distance *d*, which in this instrument is 0.100 in., separates the tracer point and the small hinge *h*. This hinge has an initial bend downward to insure good contact between the tracer point and the unknown surface. In the half-tone the tracer point is resting on a gear tooth, which is the "unknown surface." The pilot surface is behind the arm and consists of a single polished tooth. The center of the pilot gear is displaced a distance *d* from the center of the gear to be measured; thus the pilot point and the tracer point rest on corresponding parts of a tooth profile.

From this description the principle of operation is readily apparent. Simultaneous vertical displacements of the pilot point and the tracer point will change the slope of the arm, and will produce pure vertical displacements of the mirror, but since the indicating system is responsive only to *angular* displacements of the mirror, the spot of light will not move. Similarly, *relative* vertical displacements of the tracer point with respect to the pilot point will produce rotations of the mirror regardless of the slope of the arm. Hence the instrument will indicate nothing but departures of the unknown surface from the nominal curvature of the pilot surface.

A preliminary tracing of the pilot surface will prove that the indicated irregularities are in the unknown surface. This condition is fairly easy to obtain when a rounded pilot and a polished pilot surface are used.

Inasmuch as the machined surfaces under consideration consist essentially of a series of roughly parallel furrows similar to a plowed field, it was found that a wedge-shaped point



made a sharper and more satisfactory tracer than a conical point. After considerable experimentation we discovered we could get good results from a corner broken from an ordinary safety razor blade and mounted like a "V" on the surface with the long dimension parallel to the tool marks. Several linear inches of surface can be traced before the point wears sufficiently to produce noticeable changes in the curves. This distance corresponds to several dozen curves of the type shown. Worn tracer points can be changed in a few seconds by loosening two small clamp screws.

When a machined surface is to be explored the smooth pilot surface and the unknown surface (in the illustration, gear teeth) are mounted with centers displaced a distance *d* on the movable carriage at the left of the photograph. The carriage is mounted on three balls in V-ways so it moves easily and without side play by a hand-driven screw at the left. The vertical photographic drum at the right of this carriage is driven from the same screw so the two are in synchronism. A system of slits, lenses, and mirrors focuses a spot of light on the drum.

When all is ready the tracer point is placed at the root of the tooth, the photographic drum loaded, a light-tight cover placed over the instrument, the lamp (which is now outside the cover) lighted, and the small handle turned slowly the necessary distance to trace the desired path. Several runs may be made on the same chart by tilting the mirror just behind the lamp after a run, or by elevating the recording drum slightly, thus placing the trace of the next run on a different part of the record. Standard photographic paper is used; the drum is ordinarily loaded in a dark room or dark box.

The topmost group of curves on page 59 shows a typical original record of three repeat runs along the same path on the same tooth. The fidelity of repetition is quite remarkable. On the horizontal scale, which represents distances along the tooth profile, the scale is 1 in. = 0.07 in., while on the vertical scale, which represents surface irregularities, the scale is 20 times as great, i.e., 1 in. = 0.0035 in. Hence irregularities in the graph of the order of 0.10 in. correspond to irregularities of about 0.00035 in. on the gear tooth. Fractions of thousandths are therefore quite clearly shown.

The next set of curves shows three runs made on different parts of the face of the same gear tooth. There is a strong resemblance between these three curves, showing that most of the tool marks extended across the face.

The remaining sets show runs on three different teeth spaced approximately 120° apart on two different gears. (The fourth curve in each set is a repeat of the first and it will be

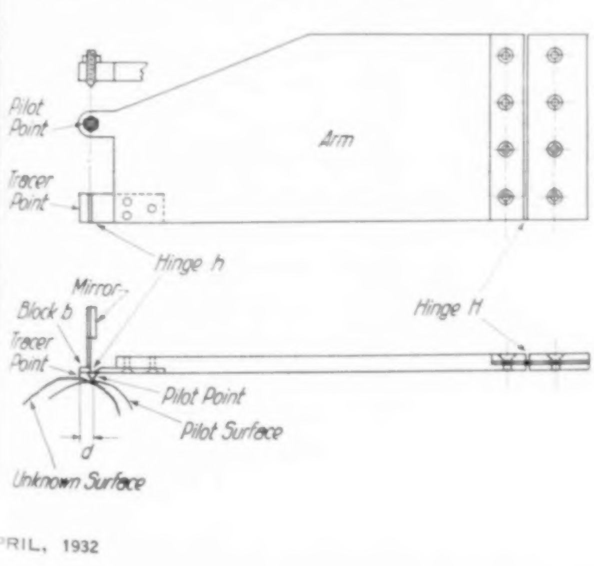
noted that the check is very good.) Each tooth exhibits different characteristics, and the two gears are quite different. The long waves in the graphs are due to differences in contour between the unknown tooth and the pilot tooth. Since all of the teeth were checked against the same pilot tooth, this is very definite evidence of variations of contour between teeth.

Such curves can be analyzed in several ways depending upon the objectives of the investigation. The general character of the surface, the magnitude of individual irregularities, and departures from contour can be read directly from the record. The amplitudes of the irregularities, which might be of some value in acoustic investigations, can be determined by means of a suitable integrator. An analysis of the periods of the components might be related to the movements of the gear-cutting machines.

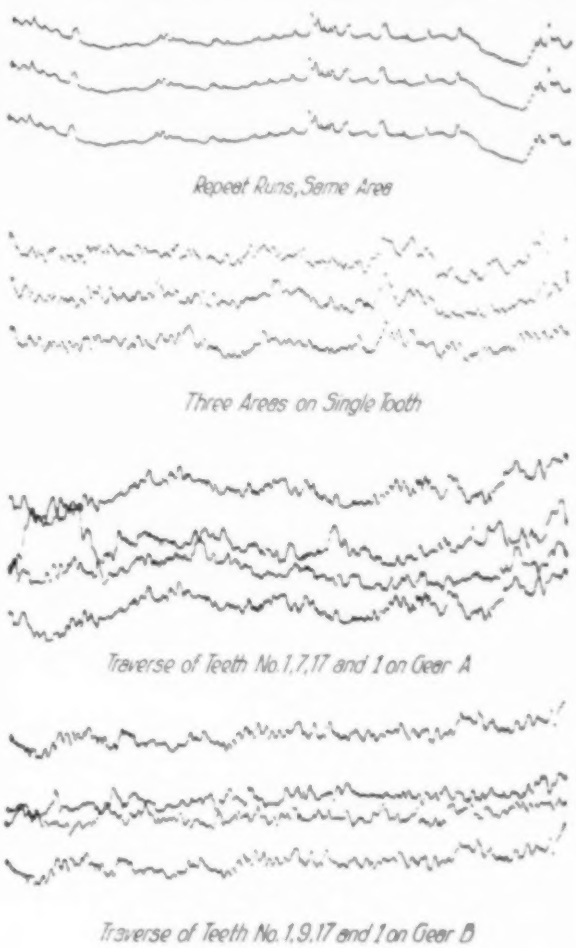
Obviously, the instrument is not limited to a study of gear teeth. By substituting a suitable pilot surface, and using proper horizontal movement and vertical amplification, almost any firm surface could be measured. For instance, it was used by the Timken Roller Bearing Co. to study the type of scoring obtained on various bearing surfaces in tests of different lubricants.

The instrument possesses several advantages. No special treatment is required for the sample to be tested, and measurements are not limited to the edges of the material but can be taken on any part of the surface to be measured. Irregularities perpendicular to the surface can be amplified several times as much as movements along the line of measurement, so that measurements may be made over a fairly long path, and at the same time allow small irregularities to be indicated.

Details of Arm Carrying Tracer Points



Typical Curves Traced on Gear Teeth



Experiments have been made with amplifications as high as 2500, but it is then difficult to obtain a sufficiently small spot of light to justify its use. An amplification of 400 to 500 seems likely to be suitable for most types of work. (In the engraving it is approximately 300.)

Another advantage of the equipment, which is perhaps the most valuable one, is that it measures small irregularities of curved surfaces without the record being affected by the normal curvature itself. For example, the curvature of the gear tooth profile would produce displacements several hundred times as great as the tool marks which it was desired to measure, and without the use of smooth pilot surfaces it would have been very difficult to obtain a record large enough to show simultaneously small surface irregularities and large surface curvature.

Calcium Improves Iron & Lead

By C. L. MANTELL, Ph.D.
Pratt Institute
Brooklyn, N. Y.
and CHARLES HARDY
President, Hardy Metallurgical Co.
New York

. . . METALLIC CALCIUM IS now available in tonnage quantities and is finding a number of uses which are both unusual and interesting. Developments of new applications have taken place, and increasing demands are being made on the producers of the metal.

In its commercial forms, calcium on freshly cut surfaces is white, approximating the color of silver. Fractured surfaces are more brilliant than steel. Upon exposure to the air, particularly in the presence of small quantities of moisture, the metal tarnishes with the formation of thin films of oxide which are bluish gray. These films are quite protective against further attack.

In contradistinction to sodium, calcium metal may be handled in a manner similar to magnesium and aluminum — that is, it may be touched and come in contact with the skin without danger. It can be machined in a lathe, turned into shapes, sawed, extruded, drawn into wire, pressed, and hammered into plates.

Calcium shows a hardness of about 2.5 on the mineralogical scale, and 42.5 Brinell (500 kg.). It is very much harder than either sodium, lithium, or lead, softer than cadmium or magnesium, harder than tin, and almost as hard as aluminum. It is relatively tough and is not brittle. Its tensile strength is 8700 lb. per sq.in.

At temperatures around its melting point (1490° F.) it oxidizes exceedingly readily and therefore cannot be cast by the usual foundry methods. When melted in the absence of air or oxidizing influences and in the presence of inert gases, it can be cast into various shapes.

Present interest in calcium is not so much concerned with its properties as the metal calcium, as its ability to deoxidize other metals, to remove bismuth from impure lead, and to harden soft metals — notably lead.

The specific cases will be discussed of calcium in cast iron and steel (where it is employed as a deoxidizer), calcium in copper (employed as a degasifier and reducer), calcium in lead (where it is used because of its alloying action), and calcium as a reagent for the removal of bismuth from lead. Finally, some information on the production of the metal and its physical properties will be presented.

Oxygen when perfectly dry has little if any effect on calcium at ordinary temperatures. In the presence of moist air, the surface of the metal is converted to calcium oxide, but thin films afford considerable protection. At higher temperatures, say above 500° F., the metal is readily oxidized. Somewhat analogous to sodium, it is a strong reducing and dehydrating agent. For this reason it has found application as a deoxidizer and degasifier for carbon steel and special alloy steels, and as a deoxidizer for non-ferrous metals, particularly copper. A number of recent patents deal with the reduction of oxides of vanadium, uranium, and chromium by means of calcium in the presence of fluxing materials such as alkaline earth metal

halides. The absorption of nitrogen and other gases by calcium has long been known as a laboratory reaction.

Metallic calcium in the form of briquettes made with sponge iron has been used as a deoxidizing agent for iron castings made in green sand molds. The amount of deoxidizer was 0.5%. Typical sections are shown. Calcium treated material shows the graphite more evenly distributed and in thinner flakes than in the untreated sample. Similarly treated cast irons gave the following analyses and properties:

	Ordinary Cast Iron	Calcium Treated Cast Iron
Chemical analysis		
Total carbon	3.31%	3.31%
Graphitic carbon	2.93	2.59
Combined carbon	0.38	0.72
Silicon	2.12	2.14
Manganese	0.42	0.43
Titanium	0.13	0.12
Calcium	0.01	0.02
Phosphorus	0.41	0.41
Sulphur	0.09	0.07
Physical properties		
Transverse strength	3800	4200
Deflection	0.15	0.15
Tensile strength	38,400	41,000
Impact	3940	4860
Brinell hardness	228	228

The analyses show that the calcium treatment of cast iron has resulted in lowering the following constituents:

(1) Graphitic carbon,

(2) Sulphur,

(3) Total insoluble residue, silica, and titanium oxide as determined by the iodine treatment,

(4) Total insoluble residue, silica, and titanium oxide as determined by the 20% hydrochloric acid treatment,

(5) Total insoluble residue, silica, and titanium oxide as determined by the 33% nitric acid treatment.

The calcium treatment has also resulted in raising the following constituents:

(1) Combined carbon,

(2) Calcium,

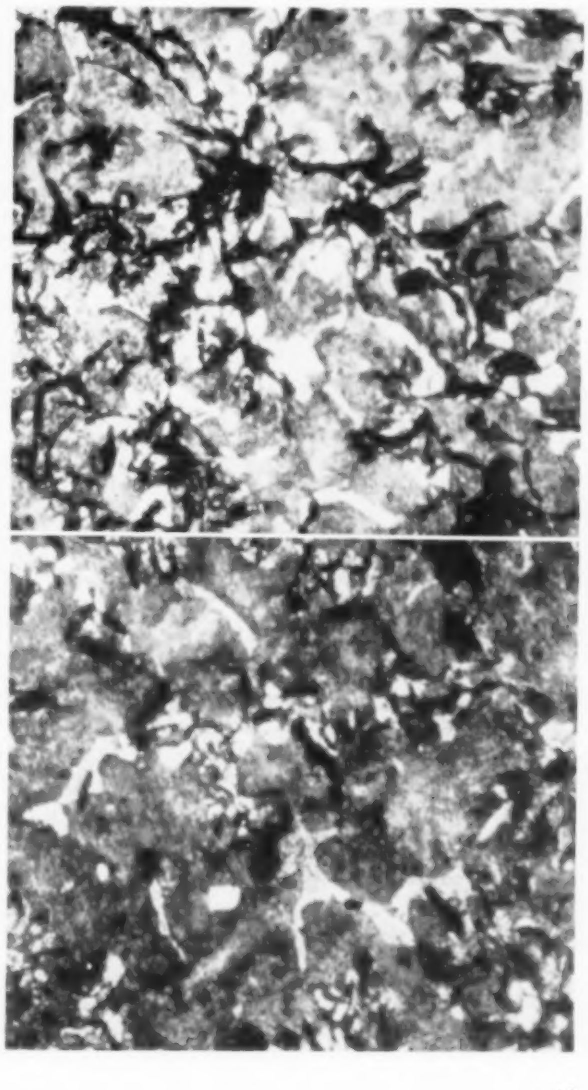
(3) Manganous oxide of the iodine residue,

(4) Manganous oxide of the hydrochloric acid residue.

The photomicrographs, especially those unetched at low magnifications, show that the graphite in the calcium treated cast iron is present in the form of thin and fairly uniformly distributed flakes, in contrast with the graphite found in the ordinary cast iron, which is in the form of thick and more or less segregated flakes. The addition of calcium to the cast iron has raised the impact values and increased the transverse and tensile strengths. Calcium treated cast iron shows a more uniform grain structure than untreated material.

In one commercial foundry test, the solidification shrinkage of ordinary cast iron was 0.15 and that of calcium treated cast iron 0.164. This would indicate that a denser product had been made. Calcium treated cast irons have characteristics of the high quality or high test cast

Photomicrographs at 275 Diameters of Gray Cast Iron (Top) and the Same Melt Treated With Calcium Show Thinner and More Uniformly Distributed Graphite Flakes in the Latter



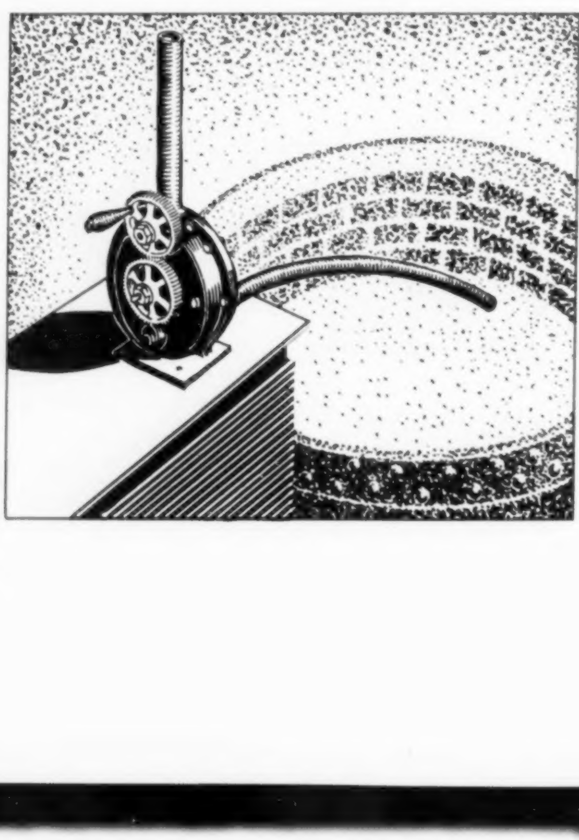
iron as described by Moldenke, having tensiles greater than 30,000 lb. per sq.in. and transverse strengths greater than 2500 lb. per sq.in.

Good results have been obtained with steel, the calcium functioning as an effective deoxidizer and degasifier, thus producing cleaner steels. It has the advantage over other deoxidizers that practically none of the reagent is left in the metal. Improved characteristics of the steel are shown in higher yield points and greater tensile strength.

Methods had to be developed for introducing the calcium metal into the steel. Briquetting with sponge iron or steel chips gave only partial success. Mechanisms were finally developed by means of which slugs or pieces of calcium were shot into the ladle of molten metal through an air pressure gun. Sufficient force can thus be applied to the calcium projectile to shoot it deep into the metal where it reacts, disintegrates, does its deoxidizing, and is converted into lime which rapidly rises to the slag.

Originally, projectiles of specific shape were employed, but later modifications of the gun use irregular chunks of calcium weighing about 2 oz. apiece. At the present time, slugs can be shot at the rate of 120 to 150 per min. when the gun is hand operated, or 200 to 300 per min. if it is motor driven, and a 60-ton ladle of steel deoxidized in a period of approximately 5 min.

Hand-Operated Calcium "Gun" for Shooting Pellets Into a Stream of Steel, Thus Submerging the Reactive Metal so It Can React With Gases in the Metal



when 2 lb. of calcium per ton of steel is used.

The effectiveness of calcium as a deoxidizing and degasifying agent for copper is well known. A method of carrying out the deoxidation by the use of calcium was described as early as 1906, and it was claimed that sound copper can be readily produced of sufficient ductility to permit wire drawing. Masing found that when calcium is used as a deoxidizer, cast coppers of high conductivity and high density are produced. During his work, however, inconsistent results were obtained.

Deoxidizing Copper With Calcium

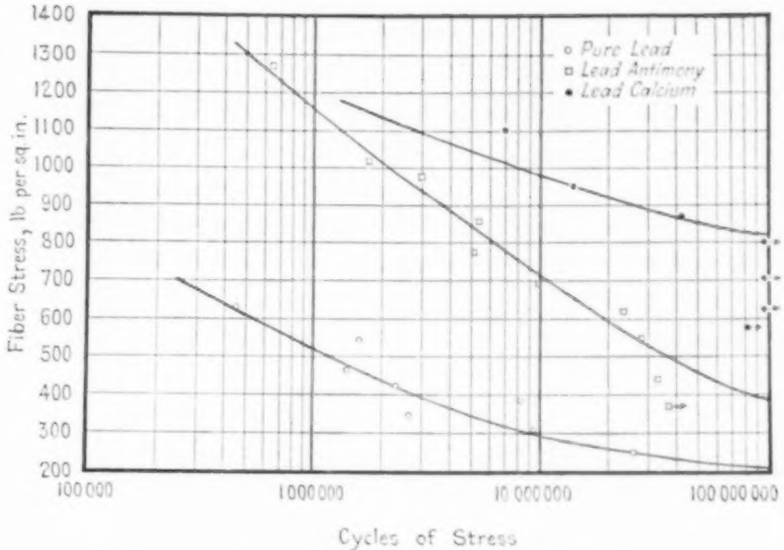
Schumacher, Ellis, and Eckel studied the copper-calcium alloys containing from 0.06 to 0.8% of calcium (*Transactions*, A.I.M.E., 1930). These were made by the use of a copper alloy containing 6.6% calcium, the copper alloy itself being prepared from metallic calcium and copper. The authors concluded that small amounts of calcium effectively deoxidized copper without materially impairing mechanical properties and electrical conductivity, provided the residual calcium is kept to a small percentage. Deoxidized copper is especially valuable for its high ductility, uniform grain size, and its welding qualities.

In further studies they compared zinc, beryllium, barium, strontium, and lithium as copper deoxidizers and concluded that the use of metallic deoxidizers has a disadvantage in that the excess metal usually alloys with the copper and diminishes the conductivity. To reduce this effect to a minimum, it is necessary to know within close limits the oxygen content of the copper prior to deoxidation. When the effects of the residual deoxidizers calcium, zinc, and beryllium are expressed in terms of equivalent oxygen and plotted, the curves show that calcium has somewhat less effect on the electrical conductivity than either zinc or beryllium.

Both barium and strontium are also satisfactory deoxidizers for copper. In addition, these elements appear to have a very limited solubility in copper and therefore decrease the conductivity but little. It is doubtful if at the present time either of these elements could be used commercially on account of the high cost. Lithium satisfactorily deoxidizes copper, but

has definite limitations since it combines rapidly with the oxygen of the air and produces some refractory oxides.

In the study of the copper-calcium alloys, it was found that all those below 0.8% calcium were ductile and could be drawn into wire. The strength and hardness were slightly increased and ductility decreased as the calcium content was raised. Electrical conductivity of the copper was decreased 1% by each 0.05% of calcium. The calcium-copper eutectic contains 5.8% calcium and has a melting point of 1670° F. $CaCu_4$ has no solid solubility in copper, hence deoxidized copper of high conductivity may be obtained by its addition to copper metal.



Endurance Curves for Pure Lead, 1% Antimony, and 0.04% Calcium Alloys for Cable Sheathing According to Townsend & Greenall, A.S.T.M., 1930

Turning now to the utility of calcium as an alloying agent, the metal has found greatest application in the preparation of low calcium content lead alloys, particularly useful for sheathing on electrical cable. The lead-calcium alloy system has been reported by various investigators, and shows the existence of compounds Pb_3Ca, PbCa, and $PbCa_2$. Alloys of commercial interest at present are those between pure lead and Pb_3Ca.

During the War the demand for shrapnel bullets caused a shortage of antimony and antimonial lead, and the lead-barium-calcium alloys known as Frary metal were developed. These hard alloys (containing up to 2% barium and 1% calcium) also found considerable favor for bearings; investigators have studied the physical properties of lead alloys up to 2% calcium for use as bearing materials. In these, large particles of Pb_3Ca cause hardening and furnish bearing surfaces.

More recently a definite range of age hardening alloys of the lead-calcium series was discovered by engineers in the Bell Telephone Laboratories and at Western Electric Co. and their properties studied for use as sheathing material for electrical cable. Some of these hardenable alloys possess properties which strongly recommended them for commercial uses. Compared with the 1% antimony alloy in lead, which was primarily recognized as the best cable sheathing material, pure lead alloyed with a few hundredths of one per cent calcium develops greater fatigue resistance, tensile strength, and hardness. These properties reach nearly constant values shortly after extrusion into the cable sheath because of the rapid rate of precipitation of calcium from solid solution, and the slow rate of subsequent diffusion and agglomeration of calcium (or the molecule Pb_3Ca). The 1% antimony alloy continues to change even after a period of years.

Experiments on corrosion resistance show the lead-calcium alloy to be so little different from the lead-antimony alloy as to have no appreciable effect on the life of the cable. Laboratory experiments indicate that the age hardening lead-calcium alloys are far less susceptible to fatigue failure than lead-1% antimony alloy.

Typical values on samples aged one month from Bell Telephone Laboratories follow:

	Pure Lead	1% Antimony	0.04% Calcium
Ultimate strength, lb. per sq.in. (rapid test)	2100	3300	3100
Elongation in 2 in.	92%	44%	68%
Creep under constant load starts at approximately, lb. per sq.in.	400	400	800
Endurance limit, lb. per sq.in.	215	390	730

Slight Amounts of Calcium in Lead Increase Fatigue Resistance, Tensile Strength and Hardness of Telephone Cable Sheathing

Large scale field tests of these lead-calcium alloys on commercial telephone and cable lines are now being conducted. They will serve as final criteria of the commercial usefulness of the alloys. The manufacture of cable sheaths for electrical lines requires so much lead that it is ranked as one of the three major consuming industries.

A number of other calcium alloys, such as those of aluminum and other non-ferrous metals within specific ranges of calcium content are brittle and may be readily pulverized. These alloys provide a method of manufacture of metal powders which is competitive with the present mechanical methods. Some of the calcium alloys, such as those with nickel, show high electronic emission characteristics and are useful for spark plug wires.

Calcium as a Reagent

Use of calcium as a reagent for removing bismuth from lead, so that the remaining metal is suitable for white lead manufacture, has received considerable attention. When metallic calcium is introduced into molten lead, calcium-bismuth drosses are formed, the bismuth in the lead is reduced to less than 0.05%, and the last traces of arsenic, antimony, silver, and copper are removed.

Use in Lead Industry

During the year of 1931, the American Smelting and Refining Co. has further developed this. In its simplest application it is very similar to the desilverization of lead bullion with zinc. Corresponding to the zinc used in desilverization, a lead-calcium alloy, containing approximately 3% calcium, is usually employed. The reagent is incorporated into the bath by stirring with the ordinary type of lead mixing machine. Other processing, such as cooling, blocking out, and finally reducing the bath close to the freezing point of lead, follows desilverization operations. Return circulation to succeeding batches of new lead are also employed. The main point of difference is that the temperature range of these operations is much lower, which prevents undue oxidation of the calcium during processing operations.

After the debismuthizing action is complete

and the concentrated bismuth crust is removed, there remains dissolved in the lead a portion of the original calcium added. This is removed by chlorine gas in a step quite similar to the process employed to dezinc lead with chlorine. Subsequently, and in a separate kettle, the fused chloride thus recovered is used for further processing of the bismuth crust.

Concentrations, quite comparable with silver concentrations obtained in the desilverization of lead, are here effected with respect to the concentration of bismuth. The end product consists of lead-bismuth alloys which correspond, in bismuth content, to the bismuth content of the bullion treated. Final lead, of corroding quality, can be regularly obtained.

Manufacture of the Metal

Metallic calcium is produced commercially by the electrolysis of fused calcium chloride. The cell uses the principle proposed by Rathenau in 1904, and indicated in the accompanying sketch from P. H. Brace's "Notes on Calcium" presented to the British Institute of Metals in 1921. At the start the water-cooled cathode *H* just touches the surface of the molten electrolyte, and is operated at such a current density that the surface of the deposited calcium in contact with the electrolyte is kept molten. This cathode is gradually elevated as the metal accumulates, and a rod of calcium of indefinite length produced. *G,G* are water-cooled añodes of graphite, movable sidewise. Alternating current is brought in via switch *S* to melt the electrolyte at the start; then direct current from *E* is used to carry on. The cell *A* is of graphite, water-cooled at *C* at the bottom and insulated at *F* at the sides. *D* represents a skull of unmelted electrolyte.

Such calcium is generally 98.5 to 99% pure with impurities mainly consisting of oxygen, small impurities of sodium, aluminum, and iron, as would be found in the calcium chloride, from which the metal is produced.

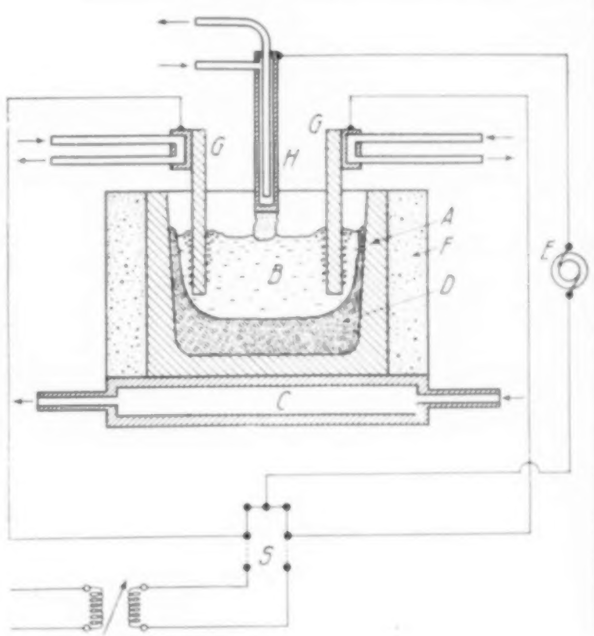
The price of calcium, which but 15 years ago was still in the neighborhood of $20 per lb., is now about $1.50. As its uses and therefore its production increase very considerably price reductions may be contemplated. The increased volume of consumption should allow its ultimate production at a cost in line with the other alkali metals.

Various forms of the metal are now available to the users. In irregular lumps, 2 to 4 in., it is packed in 100-lb. cases (tin-lined) or 10-lb. tin cans. It may also be had in 2-oz. pellets, in shavings of various degrees of fineness, and in sticks or extruded wire. Incidental loss by oxidation on short exposure at normal temperatures is small.

Pure Metal Recommended

Some have advocated the use of low-calcium alloys or calcium compounds instead of the pure metal. (For instance, lead-calcium alloy may be made as Frary metal is made — by electrolysis of calcium chloride using a layer of molten lead for the cathode; this absorbs and alloys with the calcium as it is formed.) In our opinion, the pure metal should be used wherever possible. A remarkable evolution of heat occurs when pure calcium is alloyed with metals — this is noticeable when making ladle additions to steel of no more than 2 lb. per ton. Should a calcium alloy be used in place of the metal, this heat of formation would be extracted from the melt and correspondingly chill it before the metallic calcium is freed for its work.

Sketch of Cell for Manufacturing Sticks of Calcium Metal on Rising Cathode H by Electrolysis of Fused Calcium Chloride



Driving the Last Joint

Photo by Louis W. Hine

Heat Treating Rivet Sets

. . . LAST NOVEMBER A SUB-committee of the Recommended Practice Committee of the American Society for Steel Treating adopted a tentative recommended practice for heat treatment of rivet sets which is given below. It is not intended to be a specification, and should not be interpreted as such, but will remain a tentative recommended practice until approved by the board of directors of the Society. Meanwhile, criticisms are solicited, and should be sent to the committee's secretary, J. E. Donnellan, 7016 Euclid Ave., Cleveland.

The recommendations apply to two classes of rivet dies, first, those used in portable pneumatic equipment which strike rapid blows (such as an air gun), and second, those used in compression or hydraulic equipment, which work by steady pressure rather than by blows.

The first class, which for convenience will be called "pneumatic rivet sets," includes seven types of steel. Chemical composition and recommended forging and heat treatment routine are given in the table below. The last steel, silico-manganese, may or may not contain chromium up to 0.50%, vanadium up to 0.25%, and molybdenum up to 0.50%. If it contains the latter element it may be quenched from 1575 to 1650° F. in oil.

When quenching, it is recommended that the rivet sets should be completely immersed while a stream of the quenching medium is being forced into the cup. It is good practice to hold the rivet set with a special pair of tongs which keeps the water away from the ring, but at the same time permits uniform cooling of the cup and shank. Sets should be tempered all over at the temperatures given. (All temperatures are in degrees Fahrenheit.)

The second class of rivet sets, which for convenience may be called "hot pressing sets" includes two types of steel, (*a*) a carbon-chromium steel containing 0.85 to 1.00% carbon and approximately 3.75% chromium, and (*b*) a tungsten-chromium-vanadium steel containing 0.35 to 0.45% carbon, and approximately 10% tungsten, 3% chromium, and 0.5% vanadium.

Forging range of the first-mentioned is 1900 to 1650° F. Annealing should be done between 1475 and 1525° F. Quench from 1750 to 1850° in low pressure air blast or in still air. If quenched in air blast the tempering temperature should be between 950 and 1100° F. Rockwell hardness should measure C-43 to C-50.

Higher temperatures are used for forging and treating the 10% tungsten steel. Forge from 2050 down to 1800° F. Anneal between 1600 and 1650. Preheat about 100° below the annealing range, then heat quickly to 1850 to 2150° F. and quench in oil or air. Temper within the range 1050 to 1250° F. for hardness of C-45 to C-50.

COMPOSITION AND TREATMENT OF PNEUMATIC RIVET SETS

Type	Chemical Analysis					Forging Range	Normalizing Temperature	Annealing Temperature	Hardening Temperature and Medium	Tempering Temperature	Rockwell Hardness C Scale
	Carbon	Manganese	Chromium	Vanadium	Others						
Carbon	0.70 to 0.90	0.30	–	–	–	1800 to 1600	1475 to 1525	1425 to 1450	1425 to 1500 in water or 10% brine	425 to 550	54 to 59
C-V	0.70 to 0.90	0.30	–	0.20	–	1800 to 1600	1475 to 1525	1425 to 1450	1425 to 1500 in water or 10% brine	425 to 550	54 to 59
Cr-V	0.45 to 0.60	0.35	0.80	0.20	–	1900 to 1600	1600 to 1650	1450 to 1500	1475 to 1550 in water or 1550 to 1600 in oil	450 to 600 450 to 600	52 to 57
Cr-V	0.45 to 0.60	0.55	0.80	0.20	–	1900 to 1600	1600 to 1650	1450 to 1500	1450 to 1525 in water or 1550 to 1600 in oil (preferred)	450 to 600 450 to 600	52 to 57
Cr	0.55 to 0.70	0.30	0.50	–	–	1900 to 1600	1550 to 1625	1450 to 1500	1450 to 1500 in water	450 to 550	54 to 59
W-Cr-V	0.40 to 0.55	0.30	1.25	0.25	2.0 W	1900 to 1700	–	1475 to 1525	1650 to 1750 in oil (preferred) or 1550 to 1600 in water	450 to 600 450 to 600	52 to 57
Si-Mn	0.45 to 0.60	0.75	Optional	Optional	2.0 Si	1800 to 1600	1600 to 1700	1475 to 1525	1550 to 1625 in water	550 to 700	52 to 57

Correspondence and Foreign Letters

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Origin of the Word "Sonim"

PLAINFIELD, N. J. — The remark in the editorial in February METAL PROGRESS that the word "sonim" is highly artificial, makes an explanation in order. In 1908 or 1909, when I first began writing about such things, it seemed wasteful to repeat "solid non-metallic impurities," or a substitute therefor, each time they were referred to in the thought. A name was demanded. It is, of course, a distinct advantage to have a name for a new thing and particularly a short word meaning only that thing.

Inspired by Charles Dickens, who made up names for his characters by taking one syllable from one name and another syllable from another, I took the initial letters from the three words and "so-n-im" resulted.

I never approved of adding words to our language, which is anyway a hash of many, by coining long ones from Latin and Greek roots to indicate meanings which are usually quite beyond the knowledge of the ancients. As I said at the time, in answering a criticism of sonim as "metallurgical slang": "Once a name is attached to a thing, its origin may be forgotten but its usefulness remains." Short Saxon words, which are our best, are of unknown origin.

HENRY D. HIBBARD

Wrought Iron Disappearing From Europe

BIRKENHEAD, ENGLAND — In the course of a long experience I have rarely heard a more discussed metallurgical matter than the question of the suspension of the building of the new Cunarder at Glasgow. The Cunard Line, of course, typifies English shipping and its "Mauretania" and the "Aquitania" are very familiar to Englishmen. The new ship was to restore to this country the blue ribbon of the Atlantic, and incidentally to give the heavy steel trades a very useful fillip. The ordering of the new "Bermuda" at the Vickers works would also have helped to persuade shipowners that now is the time to build ships, a situation which would help the steel maker very materially.

One metallurgical industry which is feeling the strain acutely at the moment is the manufacture of wrought iron. Since the introduction of steel for shipbuilding, the wrought or puddled iron industry has had a very checkered career, and at the moment, I doubt very much if there are three firms in England which could produce 3-in. bars for cable making. With the nearly complete absence of new sea-going tonnage the demand for anchor cable is practically nil. This is a very serious position for the industry, since the production of this material depends almost entirely upon the skill of the worker. The job is a heavy one and personal efficiency is largely dependent upon constant employment. I well remember, after the slump of 1922, watching men attempting to make $3\frac{1}{2}$-in. cable. Their hands and arms were soft and thoroughly out of condition and their efforts were pitiful.

Speaking of wrought iron, it is curious to note that it is practically unobtainable in

Europe, except in England. I was once commissioned to tour Europe to find a supply of wrought iron. I was only successful in finding one or two places where puddled iron was produced, and here only for internal consumption, and not for the market. I was offered a large number of alternatives of the nature of Armco iron, but never the genuine puddled iron. It is also interesting to note that the production of wrought iron is one of the few things which has baffled the Japanese. The quays at Birkenhead to this day still show large piles of old horseshoes and other wrought iron material for shipment to Japan, there to be reheated and forged into various implements.

Wrought iron has been credited with various properties and frequently has been stated to resist corrosion much more than any other ferrous metal. This may or may not be true, but generally, its most important metallurgical property is overlooked — its true elastic limit of approximately half its ultimate stress. It therefore has a considerably higher elastic limit than mild steel of ship quality. Failure to appreciate this point has led to numerous failures in the transition from wrought iron to steel ships. I have an intrinsic faith in wrought iron and my working motto will always be, "When in doubt, use wrought iron."

F. Grimshaw Martin

Correspondence and Foreign Letters

CANSTATT, Germany — With the construction of long distance pipe lines, fuel gas has been brought from coal fields to the principal metallurgical districts of Germany at a greatly reduced price. One result has been a lively competition between the adherents of gas-fired and electrically heated annealing furnaces, and this competition has brought forward several new designs, some of more than transient interest.

Changes in gas-fired furnaces have mainly been directed toward improvements of details — important enough as far as economy is concerned — but in electric furnaces the change has been more pronounced. A new principle has been gaining headway in the form of new designs developed by Messrs. Junker and Musokowitz. They build their furnaces as lightly as possible and equip them with the best possible heat insulation.

Resistors Embedded in Muffle Wall

Electricity is necessarily a very expensive source of heat units and electric furnaces are generally economical only when such advantages can be gained in regard to design and use that the high cost per heat unit is counterbalanced by definite advantages in other respects. Such a field is present in annealing furnaces for metal blanks, strips, and bands.

Pack annealing and box annealing of such material has heretofore been extensively used by German manufacturers. The product is, however, not up to the present-day requirements for uniformity. According to recent investigations made by H. Roth, a stack of 0.03-in. brass sheets 2 ft. high, when annealed in a container, will show a very considerable difference in the rate of heating for the different layers. The top sheets will reach the annealing temperature (850° F.) in about $1\frac{1}{2}$ hr., whereas the sheets in the center of the pile will reach the same temperature only after 6 hr. heating time. The grain size, surface conditions, and deep drawing qualities of the sheets will evidently be very uneven after such treatment.

This older practice is now being abandoned in Germany; continuous furnaces are coming into use, thereby following the American example. It is in the design of such furnaces, electrically heated, that the new design has been most successful.

Correspondence and Foreign Letters

Two important considerations for any furnace are (*a*) how many heat units does it take to bring it to working temperature, and (*b*) when this temperature is reached how many heat units are required in unit time during production. For electrically heated furnaces the first point mentioned cannot be overlooked, because most of them require a very long heating period. A heavily built furnace may have and often does show a good heat economy when once brought to the working temperature, but the time and heat required to bring it up are comparatively long. When a furnace can be run continuously, this may not be a serious drawback, but in these troubled times, with short-time work, it is often impossible to maintain a continuous operation for a single day.

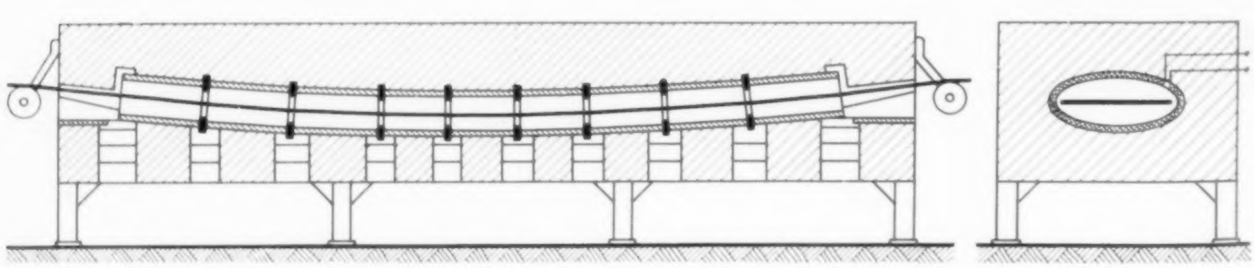
The principle used by Junker and Musokowitz in the design of their furnaces is shown in the sketches. The muffle is surrounded by powdered kieselguhr or silica earth in layers up to 1 ft. thick. According to Mr. Musokowitz, such a wall, when the internal temperature is about 1300° F., will have an outside temperature of only 90 to 100° F., whereas a furnace made of a wall of firebrick and one layer of first-class insulating brick, at the same internal heat, will show an outside temperature of about 160° F. The insulation efficiency is thus at least 2½ times in favor of the silica earth.

Heating units in the Junker-Musokowitz furnaces consist of chamotte muffles 1 in. thick, more or less, with the heating units baked into the chamotte mass. This is a design frequently met in smaller furnaces, especially for laboratory purposes. A number of sections are used in the long furnace shown. This arrangement is adaptable to different voltages and has the further advantage that if a section should burn out it can be replaced at a reasonably low cost. It is also quite feasible to equip some regions — for instance, where the cold work enters — with units producing more heat.

In comparison with conventional designs where the heating units are in the form of bare ribbons, hung on firebrick supports, the new type has the advantage that the gross furnace volume (interior space) can be made smaller for the same capacity and more suitably shaped to the material to be handled. The heat can also be supplied to better advantage, as the ribbon-type furnace can infrequently be heated from all sides of the cavity.

Excellent results have been obtained with this new type of furnace in regard to heat economy. In a continuous furnace of the type shown, 1 ton of brass sheets requires about 73 kw-hr. for annealing at 900° F. This corresponds to a thermal efficiency of about 80%. Older types of furnace require as high as 110 kw-hr. under the same conditions.

This principle in furnace design has also been applied in the construction of closed muffle furnaces for annealing purposes. These chamotte muffles with imbedded heating units are placed one on top of the other and the space between the muffle and the steel shell is filled



Plan and Cross-Section of Tube Furnace of Formed Sections With Embedded Resistors

with loose silica earth insulation. Excellent heat economy has also been obtained with these designs.

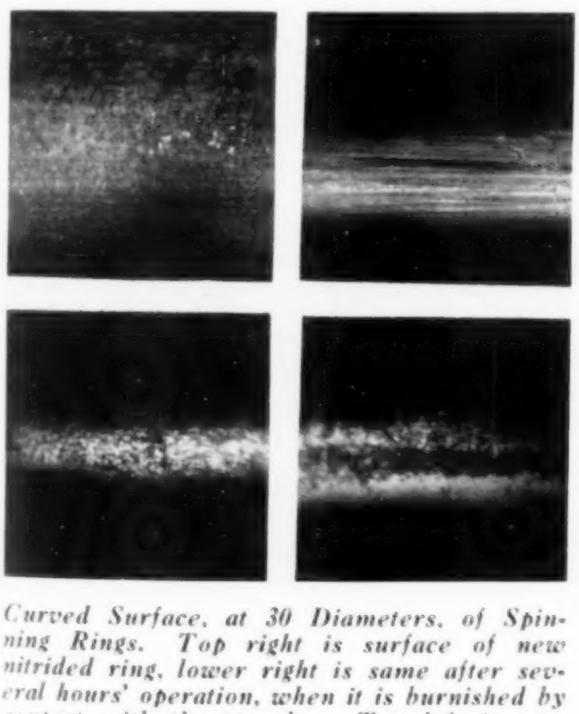
E. W. Ehn
H. Diergarten

Correspondence and Foreign Letters

Smoothness of Nitrided Surfaces

Odamura, Japan — Machine parts, nitrided for hardness, have been applied to many classes of equipment, but as far as the writer is aware, the French are the only manufacturers of textile machinery who have extensively applied the process. We in Japan, at the Nihon Spindle Seizosho, are finding that nitrided spinning rings are giving excellent results. Their virtue consists of extreme hardness to resist frictional wear, freedom from objectionable warpage, high resistance to corrosion, and a smooth surface characteristic of the process of nitriding after polishing.

As the hardening process is carried out after they are thoroughly polished, the new rings possess a smooth surface equal to that of "traveler burnished" rings. Consequently, that trouble is avoided which all spinners experience when running-in new rings of hardened or carburized steel, such as the wearing out and the flying off of travelers, with the consequent frequency of broken ends.



Curved Surface, at 30 Diameters, of Spinning Rings. Top right is surface of new nitrided ring, lower right is same after several hours' operation, when it is burnished by contact with the traveler. Top left is new carburized ring, polished with fine abrasive; below is same after traveler burnishing

The photomicrograph at the left shows the surface of a new nitrided ring. Compare it with the one alongside showing a new, well-polished ring of carburized steel. The lower views show the surface of nitrided and carburized rings respectively which have been burnished smooth by travelers.

The new carburized ring contains many streaks or furrows left by the abrasive material used in final polishing. So long as polishing is the last operation on the finished surface, such streaks will remain on the surface however fine an abrasive may be used. Hardened steel polished with diamond dust, when examined under a microscope, is found to contain many minute indentations from former operations and innumerable fine scratches.

In fact, the brightness of an ordinary polished surface is the result of inter-reflection of light on these streaks. The surface of a new nitrided ring is not bright but of a dull gray color. After several hours' use the surface that has come in contact with a traveler becomes bright and mirror-like.

The smooth surface of properly made nitrided pieces apparently accounts for reduced friction when at work and also for the comparatively small amount of wear. While a polished surface is covered with sharp-edged streaks, that of nitrided surface is devoid of such furrows. Friction is caused by the one or more of these ridges rubbing against similar ones on the corresponding parts. Minute metal particles are rubbed off and ground down between the

surfaces in contact, thus assisting further in wear and increased friction.

Another important feature of nitrided rings is their resistance to corrosion. Neither damp air, wet spray, nor salty atmosphere will cause on them that almost invisible film of corrosion adhering to ordinary steel rings. Such incipient corrosion is very detrimental to efficient spinning operations when first starting the machinery after a day of rest or during weather of high humidity. These facts are recognized by progressive mill managers, who insist that hardened or carburized steel rings, fresh from stock, shall be carefully polished free from acquired traces of atmospheric corrosion. This corrosion is easily seen as small discolored specks under a microscope.

As a general fact, it is well known that corrosion starts at sharp points. This may lead to an understanding of the reasons why a newly polished ring, the surface of which is full of sharp-edged streaks, corrodes more easily than another which has been "traveler burnished." The surfaces of both are equally bright to the naked eye, but in the latter those sharp-edged streaks have been worked off.

G. Kuwada, Dr. Eng.

Correspondence and Foreign Letters

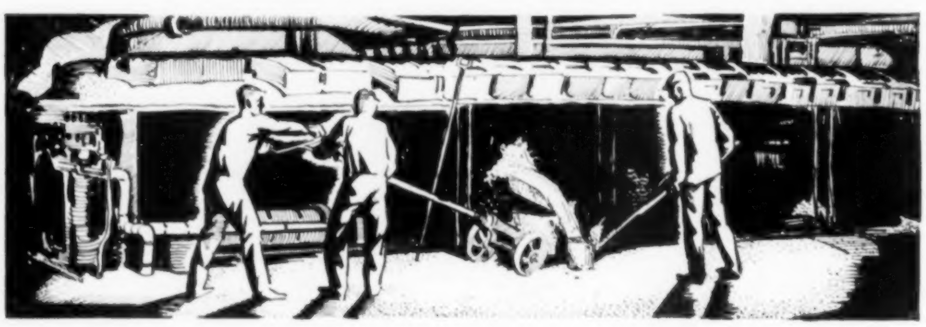
European Iron Founders Use Rotary Furnace

Turin, Italy — During the last two years Italian iron foundrymen have begun to realize the great advantages of the revolving furnace, as compared both economically and technically with the cupola or the ordinary reverberatory or air furnace. This "discovery" of a thing discovered long ago has been forced by increasingly difficult specifications for iron castings and keener price competition.

Revolving furnaces were introduced on a really large scale in the European iron foundry only three or four years ago. From the very first the Brackelsberg revolving and tilting type of furnace has been more generally used, especially in Germany. A modification known as the Stein-Brackelsberg is now becoming more popular, since it contains many important improvements. The typical features of the revolving furnaces are fairly well and widely known, and it may be of some interest to examine briefly the special conditions which have favored their adoption in Italy.

A furnace of this type, having 1 to 1½ tons capacity, has a cylindrical steel shell about 5 ft. diameter and 8 ft. long. Ends are conical, and the shell is lined with proper refractories. There is an axial opening at each end, one for the insertion of the fuel burner, and the other (somewhat larger) for venting the products of combustion and for loading and unloading the furnace.

Surrounding the shell and attached to it are tires which rest on trunnions and by means of which the furnace is kept revolving. During the melting stage the axis of the furnace is horizontal, but the trunnions and driving mechanism are themselves mounted in a cradle so



the furnace can be tilted through a considerable angle, both so the vent is upward for receiving a charge, and sharply downward for draining the melt.

Pulverized fuel has been used for the early furnaces, the luminous flame heating the furnace lining and its contents at a rapid rate. Strong draft prevents any ash from depositing within the shell and contaminating the contents. Such rapid melting (usually under a prepared slag) also produced liquid metal containing a minimum of gas.

Wherever the peculiar technical advantages of the revolving furnace predominate over the economic factors, the developments in the iron foundries have followed practically the same lines. This applies especially to the production of high quality iron castings, either alloy iron or pearlitic iron. The facilities afforded by the revolving furnace for obtaining iron of an exactly predetermined composition and superheat and for preventing the absorption of impurities from the fuel are of the greatest importance.

In all such instances, the economic considerations are more or less secondary, and revolving furnaces would be installed despite local prices of available fuels. This explains why European iron foundries specializing in the production of high quality castings are rapidly replacing their cupolas and reverberatory furnaces with revolving furnaces, independent of the prevailing costs of oil, coke, and the different qualities of coal. Most of the foundries making alloy iron castings, or, indeed, any kind of high quality castings, use oil heated furnaces of small sizes with capacity varying between two and five tons. Now and then a coal heated furnace of larger size — say, 20 to 30 tons capacity — is used for these special purposes.

Frequently, small oil heated revolving furnaces are duplexed with the cupola. The latter is then used only to melt the pig iron at the lowest possible temperature (thus avoiding troubles and imperfections originating in the cupola from an excess of air and from chemical reactions between impurities in the coke and the overheated iron). Cold liquid iron is then transferred to the preheated revolving furnace, where the final additions are made for obtaining the proposed composition, and the necessary overheating achieved.

Correspondence and Foreign Letters

Remarkable technical and economic advantages of this duplex process have resulted, especially when a strong overheating is required. For example, an oil heated, continuous, revolving Stein-Brackelsberg furnace of $1\frac{1}{2}$ tons capacity can easily supply, at 40-min. intervals, between 3200 and 3500 lb. of iron of an exactly predetermined composition, at a temperature of 3000° F., using sluggish cupola iron at 2300° F. and about 6 to 7% of fuel (based on the iron produced). Starting from a cold charge of iron and steel scrap the same furnace takes from $2\frac{1}{2}$ hr. to 3 hr. to produce the same iron at the same temperature, with about double the fuel consumption.

While the revolving furnace has been favored mostly by the producers of high test irons, it is known that a large revolving furnace, heated with pulverized coal, has been quite successful in manufacturing ordinary iron castings. From an economic point of view, the profits depend upon the ratio of the cost of pulverized fuel and of cupola coke.

Federico Giolitti

PARIS, France — Metallurgists in all ages, searching for reasons for what they do not understand, blame the oxidation of steels and cast irons — all the obscure phenomena, all the unexplained properties have been imputed to that factor. Yet it must be confessed that even yet our knowledge relative to the influence of oxygen is far from precise and certain. In fact, it is incomparably backward when compared to what we know about the influence of the other elements contained in steel.

This is mostly due to the lack of analytical

Correspondence and Foreign Letters

Analysis of Oxygen in Steel

methods (or the difficulty or inaccuracy of such methods as are known) for the determination of oxygen and oxides in steel. On the other hand, the other common components have long since been determined easily and quantitatively.

Moreover, we cannot get a sufficient notion of the influence of oxygen by merely determining the amount in the alloy. Similarly, the carbon analysis does not allow us to know and to define its effect on steel. It is necessary also to know the state (whether free, combined, or dissolved) and the structure (that is to say, the fineness, the form, and distribution) of the components it produces in the steel.

Although the study of oxidation is so fragmentary, the basis and starting point for future work will be the precise determination of the oxygen content. This is a problem which cannot be discussed fully here, but it will be useful to state briefly (but with exactitude) the present state of such a fundamental question.

Methods for the determination of oxygen in steel may be divided into two classes, first, the reduction methods, and second, the analyses of residues.

Reduction of the dissolved oxygen or the oxygen combined in part or in all the oxides may be done by means of (*a*) hydrogen, (*b*) carbon, and (*c*) aluminum. The analyst then measures the products of the reaction (water, carbon monoxide, or alumina respectively).

Latest researches show that the old method of reduction by hydrogen can be applied only to low carbon steel containing no silicon nor phosphorus. The causes of errors are numerous and the necessary corrections important enough to leave no hope for an improvement in this method.

On the contrary, the carbon reduction in vacuum has recently been raised to a high degree of perfection. By increasing the reduction temperature to 2900 to 2950° F. (instead of 2725 to 2775° F.), the corrections for steels containing only 0.001 to 0.002% oxygen are reduced to 5 to 10%. Heating may be done by a high frequency induction furnace, a graphite spiral resistor, or, better, one of tungsten. It is unnecessary to seek for higher accuracy, for the oxygen segregates at least as strongly as does sulphur, and is responsible for variations from one sample to another greater than the experimental errors. At present, the method must be limited to steels with less than 1.5% manganese and less than 0.5% aluminum.

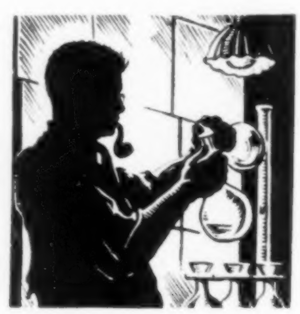
In order to determine the percentage of FeO in liquid steel it has been proposed to reduce a sample of metal already treated with aluminum and to determine the alumina produced. This method belongs to the second subdivision:

Analyses of residue, the iron having been dissolved or volatilized.

We have known for many years the method whereby the steel is dissolved in a liquid by means of halogens (such as bromine or iodine) or by metallic salts (such as the mercurous chloride). This is long, laborious, and often very inaccurate.

Volatilization by means of chlorine, on the contrary, seems to be successfully suited to the quantitative determination of silica and alumina and, eventually, of lime and magnesia. In this method it is necessary to purify the chlorine and to avoid oxidation by atmospheric water vapor. Drillings must not be employed, but solid test pieces previously coated with zinc.

According to results recently published, it should be possible to separate silica from alu-



mina, sulphides, and also from manganese oxide by electrolysis.

Lastly, and to have a complete enumeration, one must mention the method of solution in hydrochloric acid to determine alumina in steels previously reduced by aluminum.

Every proposed method must be thoroughly studied by several experimenters to determine its accuracy and to find all the causes of errors. Some of the latter may be unknown for a long time — as, for instance, surface oxidation of the metal which often excludes the use of drillings or filings in favor of massive test pieces. Some such thing may happen to the two methods which now seem to be the most perfect; namely, the determination of total oxygen by reduction in vacuum with carbon, and the determination of alumina and silica after volatilization by chlorine.

It will be also necessary to study how these methods apply to alloy steels, in which we may eventually find some complex compounds formed by these special elements with oxygen, carbon, and iron.

After we have discovered methods which will certainly give a quantitative determination of the sundry oxidized components that are in steel, then and then only can we approach the fundamental problem of the influence of oxygen and inclusions on its properties and quality.

ALBERT PORTEVIN

Correspondence and Foreign Letters

Design of Die Casting Machinery

NEW YORK, N. Y. — Some comments are necessary to clarify points raised by Ernst Seidewitz in January *Mechanical Engineering* and "concentrated" on page 72 of your February issue. Mr. Seidewitz has missed one basic distinguishing feature in the design of die casting machines, that is, whether the metal shall enter the die along the parting plane of the dies or at right angles to it. In the industry, these two types are designated "split gate machines" and "center gate machines." After one selects from the above two types the question of direction of motion of dies and goosenecks is still open, whether the metal shall enter by up-flow, level-flow, or down-flow.

In my opinion, the important considerations are not whether the metal flows up or sidewise, but (*a*) whether the metal flows along the parting plane or at right angles to the parting plane through one-half of the die, and (*b*) whether the parting plane is horizontal or vertical.

Considering the vertical versus the horizontal parting plane, we must bear in mind the question of hazard to the workmen. When molten metal is forced under pressure into a die, there is a possibility that molten metal will squirt out of the die anywhere along the parting lines of the die. If the parting plane of the die is horizontal, then the metal is liable to squirt in all directions; if the parting plane is vertical, the metal can squirt only in a vertical plane and the operator can stand to either side of this plane of danger.

A recent survey of plants responsible for 80% of the American production, made by the writer, indicates that the die casting machines in use are not loose-jointed contraptions requiring frequent repairs, as implied by Mr. Seidewitz. Nor does experience teach that mounting and dismounting dies is a difficult and dreaded piece of work. Of course, it must be considered as non-productive time and therefore as work to be avoided as much as possible.

If properly designed, dies need not be mounted and dismounted as frequently as would be supposed. Many dies require hours to mount, whereas others can be mounted in a few minutes. If the casting being produced is one in which small cores are being broken frequently, then something is wrong with the design of the die or the design of the casting being produced and such errors should be corrected before the type of die casting machine is blamed.

SAM TOUR

Concentrates from current literature

PUBLICATIONS of the Kaiser-Wilhelm Institute during 1931 are now issued in bound form (a 300-page volume) for 33 marks by Verlag Stahleisen, Düsseldorf. An extremely wide range of subjects is covered in the 21 contributions, all the way through the **STEEL MANUFACTURING PROCESSES** from the sintering of iron ore to the extrusion of shapes, piercing of billets, and drawing of wire. Equilibrium diagrams of the important alloy systems iron-chromium and iron-nickel-chromium have been systematically investigated. Other important studies on alloy steels include the corrosion in acid of copper-bearing steels, the physical properties of cast and forged medium manganese steels, and the strength of low alloy steels at high temperatures. It is a matter of regret that the details and the results of these fundamental researches are not broadcast promptly to men in the American metal industry, too few of whom have a working knowledge of the German language.

BASIC bessemer converters in Germany usually run with an excess of lime, ranging up to double that theoretically necessary, according to James Cunningham in *Metallurgia* for February. This raises the manufacturing costs of **BESSEMER STEEL** somewhat, but the slag carries off some sulphur. Various expedients are used to reduce sulphur in the mixer (such as increasing the basicity of a thin covering of slag), or when tapping the iron from the mixer (in a thin stream to promote formation of SO_2) or by placing mixed ferro-manganese fines and lime dust in the transfer ladle. It appears that there is a lower limit below which it is improper to drive the sulphur in mixer iron. For instance, iron entering the converter with 0.10% sulphur may be blown down to 0.06%. Iron containing 0.04 to 0.05% sulphur remains about constant, and a slight pick-up is found when blowing very low sulphur iron (0.02%).

HIGH speed and free wheeling have increased the amount of heat which must be dissipated by automobile brakes to such an extent that pressed steel drums tend to warp out of round. **CAST IRON BRAKE DRUMS** have given good service on heavy duty trucks and buses, and the two metals are joined in "Centrifuse" brake drums developed by Campbell, Wyant & Cannon Foundry Co. (*Foundry* for March 1). Butt welded steel drums are sand blasted, preheated, fluxed inside, brought to proper temperature in an induction heater, transferred to the chuck of a spinning machine, and a measured amount of electric-furnace cast iron dumped in. A complete weld between the liner (a centrifugal casting) and the steel shell results — a matter indispensable for heat dissipation and durability. After the iron is solidified the drum is removed from the spinning collet, air cooled, and machined. Twelve spinning heads are mounted on a single turntable, so loading, pouring, and cleaning occur at definite stations.

EFFORTS to increase the speed of oxy-acetylene welding by increasing the size of welding tip and the heat generated by a single flame have failed because the metal is overheated, embrittled, or blown away. An increase of 30 to 40% in speed may be achieved by right-hand or backward welding (where the flame advances down the open joint ahead of the rod and the puddle). Further economies are possible by **MULTI-FLAME BLOWPIPES.** One successful process developed in this country by the Linde Air Products Co. uses a small auxiliary flame to

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heat the rod, a slightly carbonizing flame for the melting, and a simple fixture to maintain correct relationship of the flames, rod and joint. Prof. F. C. Keel, in Switzerland, writes (*Journal*, American Welding Society, February) that the speed of welding by multi-flame blowpipes is from two to three times that of a single flame, welding "forward," and has designed manual equipment for the new process. He recommends a double-flame nozzle or double tip for $^{3}/_{8}$-in. plate or less; one flame, somewhat larger, plays on the edges of the sheet, pre-heating it strongly, the other strikes puddle and welding rod almost perpendicularly, and does the melting. For thick plates a triple flame is better; the right-hand one preheats the edges, the middle and strongest melts the puddle, the left and smallest flame preheats the rod. Backfires are prevented by making the tips of refractory or insulated metal of low heat conductivity, rather than of copper.

IT IS well known that chromium-nickel steels of the 18-8 type, containing more than a few points of carbon, are susceptible to intergranular corrosion if reheated within the range 1000 to 1600° F. A plausible hypothesis for the effect is that at such temperatures complex carbides are precipitated and coalesce at the austenitic grain boundaries, a reaction which locks up chromium in the carbide faster than this metal diffuses in solid solution, thus impoverishing the grain boundaries in chromium (necessary for corrosion resistance) to the extent that these portions of the alloy become ferrite and corrodible. At the February meeting of the American Institute of Mining & Metallurgical Engineers J. J. B. Rutherford and R. H. Aborn described a quantitative method for the estimation of this **INTERCRYSTALLINE CORROSION** in austenitic stainless steels wherein samples of exact shape and reproducible surface — preferably wire — are boiled 24 hr. in a solution made of 13 grams $CuSO_4 \cdot 5H_2O$ and 47 c.c. concentrated H_2SO_4 per liter. Difference in electrical conductivity, measured before and after, is a measure of the surface fissuring accompanying intergranular attack. Discussion revealed that this test enabled the authors to prepare commercial modifications of the alloy which are immune to this defect. One very good one contains about 0.5% titanium, which possibly forms a complex carbide which diffuses very slowly. P. Payson's paper on "Prevention of Intergranular Corrosion" showed that the addition of elements like silicon and molybdenum (which form "loop equilibrium diagrams" with iron) in sufficient quantity to produce a two-phase structure of ferrite and austenite in the annealed metal will also produce highly resistant alloys. Hence the existence of ferrite in the alloy (as is often revealed by a magnetic balance) is not a sufficient criterion of its action in corrosive surroundings after reheating. Payson finds that carbide precipitates preferentially in the ferrite grains, which latter interrupt the continuity of the austenite to austenite interfaces, and may therefore offer an impediment to penetration of acid along these surfaces.

METHODS of spot welding thin stainless steel are outlined in *American Machinist*, March 3, in a description of the Budd-Micheline rubber-wheeled rail car. Structural shapes and girders are built up of 0.030-in. strip, and exterior sheathing down to 0.010 in. thick is attached by "shot welding." Parts are first securely clamped and the operator then uses portable welding tongs, through which currents as high as 1200 amp. flash for controlled times (from 0.01 to 0.001 sec.). Strength of such a welded spot is satisfactory, and it is said that no region of corrodible metal is formed, possibly because the time at heat is so small and the heated area so limited that exposed metal is not structurally changed.

ADDITION of 0.10% vanadium improved Izod impact of double normalized **MEDIUM MANGANESE STEEL** castings from about 20 ft-lb. to about 50 ft-lb., as found by W. C. Hamilton, writing in *The Iron Age* for March 3. This is due to the fact that vanadium decreases the original grain size, impedes grain growth during heat treatment, and prevents segregation of manganese. In an ordinary medium manganese steel (containing approximately 0.35% C and

Concentrates

1.40% Mn) the segregation of manganese may be so great that an annealed steel is in reality a mixture of two steels, one pearlitic and one martensitic.

HIGH vanadium in cobalt high speed tool steel has been found to increase the cutting efficiency remarkably, according to Messrs. Kinzel and Burgess. Discussion of this point before the February meeting of the A.I.M.E. brought out that carbon and vanadium must be increased simultaneously in ratio of 1 to 5 over the standardized 18-4-1 grades in order to avoid producing the soft alpha-delta phase. **A HIGH SPEED STEEL** containing 4.3% V, 1.2% C, 8.8% Co, 17.6% W, 3.7% Cr cut 6890 ft. of chip before failure, as compared with 2298 ft. for a standard high speed tool. Steels of this general class have been marketed for some time. Their Rockwell hardness is not unusually high, but they resist a file, and their ability to cut abrasive materials is probably due to finely distributed carbides which are so tenaciously held in the matrix that surfaces can be polished flat for microscopic examination only with the greatest difficulty.

A FURNACE for heat treating iron and iron alloys in hydrogen or other gases at pressures ranging from very low to 20 atmospheres is described by Paul P. Cioffi in Bell Telephone Laboratories Monograph B-623. It was discovered, by using this furnace, that the magnetic properties of common alloys are strongly affected by long-continued **HIGH TEMPERATURE HEAT TREATMENTS,** much higher than usual — in fact approaching the melting point. Pressure is carried by a water-jacketed steel bomb, cylindrical in shape. Heating elements are double spirals of 1.5-mm. molybdenum wire, wound around an alundum tube, which is centered in the steel shell and insulated from it by powdered alundum. Temperatures are measured by optical pyrometer through a small glass window at one end. This equipment has been in use for several years and may be operated at

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temperatures up to 3100° F. Other devices for heating or melting specimens by induced currents in vacuo as low as 10^{-10} atmospheres are also described.

FLASH welding 120-in. seams in 0.043-in. sheets is discussed by Messrs. Meadowcroft and Paugh of Edward G. Budd Mfg. Co. and Peter Fassler of Fisher Body Corp. in S.A.E. *Journal* for March. The two first-mentioned emphasize that alignment should be accurate to within 0.005 in., else removal of the flash and scarf will reduce the thickness on one or the other side of the joint so much that the enlarged sheet cannot be drawn in dies. Such perfect alignment requires a FLASH WELDING machine whose clamping pressure is self-contained (i.e. magnetic) and exerts no pressure on the outboard bearings, so the moving side of the machine is a freely floating mass. Mr. Fassler noted some additional requirements: An equal volume of metal must remain between edge of sheet and electrode clamp. The trim line should also taper about 3/16 in. in 120 in. so the flash starts at one end and progresses across the width of the joint. This prevents a "cold" or "butt" weld, and the entire joint comes to heat in 1 sec. with 400 kw. In flash welding the electrical switch is closed before the sheets contact, thus establishing high resistance and high heat at the starting arc, and this heat crawls along as the sheets approach each other. When the heat has worked end to end and the entire joint is "flashing," the current is interrupted and the plastic joint upset. "Overlapping of pin holes is the biggest trouble, but it can be overcome by having properly tuned-in electrodes and plenty of clamping pressure (450 to 650 lb. per sq.in.) to hold the metal while it is being bumped."

STUDIES on steels at high temperature usually intend to discover the rate of deformation under continued load. R. W. Bailey and A. M. Roberts point out that certain slow changes may occur in the structure of the steel even at temperatures encountered in steam boilers (850°

Concentrates

F.) which may impair its usefulness, and some of these possibilities were discussed before the British Institution of Mechanical Engineers on Feb. 19. Rate of **SPHEROIDIZATION** of various mechanical and heat treatments was studied, by comparing the time required at various temperatures to reach a structural condition of a check piece heated a measured time at 1250° F. These, when plotted time vs. temperature on double logarithmic paper, marked parallel straight lines as required by a theoretical formula. Lines for given samples are displaced sidewise depending on past history; cast steel is roughly 500 times as sluggish at all temperatures as superheater tubes, and cold work might increase 10-fold the rate of change in a normalized tube. Times at temperature for equivalent spheroidization in an annealed and normalized forging are as follows:

1100° F.	250 hr.	(standard sample)
1000° F.	4500 hr.	(6 months)
950° F.	19,000 hr.	(2 years)
900° F.	90,000 hr.	
850° F.	500,000 hr.	(57 years)
800° F.	3,000,000 hr.	
750° F.	20,000,000 hr.	(2300 years)

While the rate of spheroidization at 850° F. (a common operating temperature) seems amply slow, the authors believe it has the same effect on creep strength of a 0.40% C steel as 54° F.

M. VITEAUX discussed the heat treatment of rails before the International Congress in Liège last year, and his paper is summarized in *The Metallurgist* for January and February. In France the Neuves Maison is prepared to heat treat its entire rail production in lengths up to 80 ft. There the hot rails hang head down on closely spaced rollers engaging the base. A shallow trough of water is then raised and lowered several times, giving several momentary quenches to the head only in a relatively small volume of water. The result is a sorbitic structure in 0.40% carbon steel. In Germany, Maximilian Hütte and the August Thyssen Works **HEAT TREAT RAILS** up to 100 ft. long. Equip-

Concentrates

ment consists of a narrow hot bed whereon three rails may be clamped securely; the entire bed then rolls over and the rails find themselves immersed each in a small trough of water just covering the head. Hundreds of high pressure sprays then strike the running surface of the rail, producing a martensitic structure about 0.3 in. deep in the 0.40% carbon steel. Both varieties of rails pass the drop test satisfactorily. The running surface of the sorbitic rail has a Brinell hardness of about 300; the martensitic rail is about 380. Sorbitic rails show an increased life of about 50% in average European traffic. Martensitic rails are especially durable on sharp curves where abrasion of the flanges must be withstood.

A NEW metal has been discovered by means of the spectroscope on the asteroid Xerxes by a young astro-physicist, according to A. W. Frehse of the Chevrolet organization. The discoverer maintained great secrecy, and one day discovered the metal in samples from Connecticut. By further prospecting, he found the metal to exist in enormous quantities in the same state, and after reducing it from the ore (the process of which is extremely simple but closely guarded) he found its physical properties to be so remarkable that he decided to call the new metal **AUTOMOBILEIUM** because it completely covered the engineering specifications of an ideal material with which to design and manufacture all automotive apparatus. The material is now available in quantity at a cost somewhat lower than that of iron. The physical properties of the metal are: Weight about the same as magnesium; melting point can be varied to suit conditions; coefficient of expansion is slightly less than invar; modulus of elasticity is 1,000,000,000 lb. per sq.in.; ductility exceeds that of platinum; electrical conductivity is slightly greater than silver; hardness a little more than stellite; and machinability about the same as butter at 72° F. The metal requires no lubrication because it refuses to rub elbows with the commoner metals. Its chemical symbol is Bs.

Magnesium

structural metals. The outstanding characteristic is its extreme lightness. Lightness coupled with good strength in a single metal is one of the demands of the engineer in the transportation industry and of the user of portable and hand-operated equipment.

Pure magnesium, like pure aluminum, is not very strong, and the development of valuable high-strength magnesium alloys constitutes one of the worth while contributions of modern metallurgy. In some instances, noted in the table on page 38, the tensile strength and hardness have been approximately doubled and the yield point increased six to eight-fold. All of these alloys are characterized by their high ratio of fatigue endurance to weight. Special alloys have also been developed for specific purposes. Some have high thermal properties, others resistance toward salt water, while all are free from intercrystalline corrosion.

Casting (in sand, permanent molds or dies), heat treating and mechanical working of these alloys is now done on a commercial scale. Ease of machining is a big asset. Final assembly of standard shapes is done by riveting and spot or gas welding.

It is impossible to predict accurately what the future has in store, but one can call attention to a few signs of the times. The wide adoption of magnesium in our industrial life depends on four conditions:

1. Ready availability of sufficient amount of raw material,

2. Development of efficient manufacturing processes yielding a low cost metal,

3. Development of methods of casting, working, and treating the metal, and

4. Development of strong alloys which have proven dependability.

Nature has abundantly looked after the first point, while man has worked valiantly to fulfill his own part of the contract. The result is a new and world-wide interest in magnesium. The infant metal is now well able to stand upon its own feet — time only will tell what strides it will take.

Trade Pamphlets

to keep you abreast of the times

Forging Hammers—Erie Foundry Co. offers two complete booklets on its line of steam drop hammers and its two and four roll board drop hammers. Bulletin AA-86.

Welded Pipe—Republic Steel Corp. has prepared a booklet on its electric weld line pipe and casing. Manufacturing processes and performance data are presented. Bulletin AA-8.

Aluminum and Its Alloys—Aluminum Company of America has prepared the book "Alcoa Aluminum and Its Alloys" which presents data and tables on the physical and chemical properties of aluminum alloys. MM-54.

Neutral Atmosphere which makes possible the hardening of high speed steel without scale, decarburization or carburization, is explained by the bulletin, "The Sentry Diamond Block Method of Hardening High Speed Steel," issued by the Sentry Co. MM-84.

Optical Instruments—Bausch & Lomb Optical Co. has issued a new 128-page book, "Optical Instruments for Examining and Analyzing Metals. Information on establishing metallurgical laboratories; optical information for the metallographer; spectrographic analysis, etc. MM-35.

American Electric Furnace Co. have just issued a new catalogue insert No. 17 showing recent series of 6 and 8 inch electric pot furnaces for lead, salt, and cyanide work. MM-2.

Welded Construction Folder—Bethlehem Steel Co. Folder describing the use of rolled steel shapes and plates for the building of machinery parts by welding. The results are said to be sturdier construction, reduced weight, low cost, and elimination of patterns. Bulletin N-76.

Heat and Corrosion Resistant Alloys—General Alloys Co. A new bulletin is available on chrome-nickel and straight chrome heat and corrosion resisting alloys. Bulletin D-17.

High Frequency Induction Furnaces—Ajax Electrothermic Corp. New bulletin gives detailed information regarding Ajax-Northrup high frequency induction furnaces operated from static converters, for laboratory use or for small-scale production. Bulletin JA-41.

Conveyor Belt Handbook—Wickwire Spencer Steel Co. A new loose-leaf handbook, describing various types of metal conveyor belts for high and low temperatures. This includes the new heavy duty "Alpha" link belt, "Delta" plate belt and spiral type. Bulletin N-37.

High Test Welding Rod—The Linde Air Products Co. A 12-page booklet describing the qualities and advantages of high test welding rod. Extensively used for fabrication of pipe lines, pressure vessels or other welding operations where high strength and economy are required. Bulletin D-63.

Alloy Products—The Pressed Steel Co., in their new catalog, give interesting data relative to Rezistal Lite-Wate carburizing and annealing containers and other equipment. Bulletin D-67.

Thermit Welding—Metal & Thermit Corp. A 52-page booklet on the thermit welding process and its applications. Photographs and descriptions typical of its varied uses are given, showing how Thermit is fundamentally adapted when large sections are involved. Bulletin D-64.

Gears Made of Armor Plate—The International Nickel Co. Reprint of article by Robert E. Bultman originally published in May, 1931, issue of METAL PROGRESS. Booklet deals with the use of 5 per cent nickel and nickel-chrome steels for motor truck gears and pinions. Bulletin D-45.

Hy-Ten Alloy Steels—Wheelock, Lovejoy & Co., Inc. "Pertinent Points" folders covering physical properties, heat treatment and applications of all grades of Hy-Ten Special Steels. Bulletin D-22.

Recorder Controller—Bristol Co. A new booklet describes Bristol's recently announced free vane air operated recorder controller. The instrument and its operating principles are graphically described. Bulletin JA-56.

Electric Heat Treating Furnaces—Ajax Electric Co., Inc. Photographic description of new electric furnaces for annealing wrought products, such as sheet, wire, tubing, rod, etc. Bulletin D-83.

Recuperators—Carborundum Co. The complete story of Carborundum Co. recuperators for industrial furnaces, describing the type and covering operating conditions. Bulletin F-57.

Quenching—A new 80-page book, "Houghton on Quenching," containing over 30 charts and photomicrographs, has just been published by E. F. Houghton and Co. MM-38.

Nitriding Steel—Properties of a new chromium-vanadium nitriding steel developed by Union Carbide & Carbon Research Laboratories are listed in a new publication of Electro Metallurgical Sales Co. MM-16.

Chrome Brick Refractories—E. J. Lavino & Co. Folder discussing chrome brick made by a new process. Test data on spalling, sagging and hot load are given. Bulletin MM-40.

Welding Electrodes—Metal & Thermit Corp. has published a folder outlining the advantages of Murex mineral coated welding electrodes. Several types of electrodes are described. MM-64.

Globar Elements and Accessories—Globar Corp. A new leaflet containing a list of standard industrial type Globar electric heating elements and a coordinated list of terminal mountings and accessories. Bulletin N-25.

Furnace Parts—Driver-Harris Co. has issued a bulletin featuring furnace parts made of their alloys. This bulletin gives data and advantages of Nichrome and Chromax heat resisting alloys in the form of furnace parts. Bulletin N-19.

Automatic Metallographic Polishing Machines—E. Leitz, Inc. Catalog illustrating and describing the Guthrie-Leitz automatic polishing machines of the one, two and four-spindle types. The new Leitz specimen clamps are also described. Bulletin N-47.

Fatigue Testing Machine—Thompson Grinder Co. Interesting data on fatigue testing and description of the rotating beam type of fatigue testing machine are given in Bulletin D-23.

Industrial Gas Heat—American Gas Association. A veritable textbook on the uses of gas heat in industry, profusely illustrated with photographs of installations, etc. Bulletin D-10.

Ingot Molds—Gathmann Engineering Co. The subject of ingot molding is covered in a new book on this subject. Numerous illustrations of the effect of various methods of finishing and casting on the reliability of steel products are given. Bulletin D-13.

Machine Heat Treating—American Gas Furnace Co. A 16-page illustrated booklet giving information on the various types of conveyor heating machines available for heat treating on a production basis. Bulletin D-11.

Potentiometer Pyrometer—The Brown Instrument Co. 16-page booklet explaining and illustrating the principal features of the new Brown potentiometer pyrometer with special reference to accuracy of operation and ruggedness in service. Bulletin N-3.

Electric Steam Generators—General Electric Co. Booklet describing and illustrating G. E. electric steam generators for process work. A list of applications is included showing how these generators may be used in a wide variety of industries. Bulletin D-60.

Scale Prevention—Dearborn Chemical Co. Booklet describing latest scientific methods of treating water for prevention of scale, corrosion and foaming in steam boilers, dealing with related problems in connection with scale and corrosion in other power plant equipment. Bulletin D-36.

Heat and Corrosion Resistant Alloys—Michigan Steel Casting Co. A 16-page bulletin describing and illustrating various cast, rolled and fabricated alloy structures for use at high temperatures. Bulletin N-12.

"Carbonol Process for Carburizing Steels" is the title of the new 12-page bulletin published by the Hevi-Duty Electric Co. The bulletin describes the results and advantages of the Carbonol process of carburizing. Bulletin N-44.

Industrial Application of the X-Ray—General Electric X-Ray Corp. Booklet gives many examples of the use of the X-Ray in the industrial field. Profusely illustrated with radiographs of castings, welds, assemblies, etc. Bulletin D-6.

Furnaces for the Steel Industry—The Electric Furnace Co. have issued a four-page folder illustrating and listing several electric and fuel fired furnaces of various types they have installed in steel plants. Bulletin D-30.

Modern Industrial Furnaces—Surface Combustion Corp. Booklet covering the research, development and engineering activities of the Surface Combustion Corp., and their application and the advantages obtained by S-C furnace users as a result of these factors. Bulletin N-51.

Rotary Hearth Furnace—W. S. Rockwell Co. has issued a new bulletin on its furnaces of this type, utilizing either electric or fuel heat. Construction advantages are explained and diagrams presented. Bulletin R0322.

Electrotinning—Roessler & Hasslacher Chemical Co., is offering a booklet describing electrotinning with the R & H sodium stannate-acetate plating bath, giving information on methods of preparation, operation and control. MM-29.

Fuel Valve Controller—Automatic Temperature Control Co. Leaflet describes a multi-position motor operated controller used for furnace temperature and atmosphere regulator, incorporating in one unit the desirable features of several older types. Bulletin JA-82.

Metal Progress, 7016 Euclid Ave., Cleveland.

Please have sent to me the following literature as described under "Trade Pamphlets" in the April issue of Metal Progress. (Please order by number.)

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Reviews of Recent Patents

By NELSON LITTELL
Patent Attorney
22 E. 40th Street
New York City
Member of A.S.S.T.

Spot Welder, *by Raymond S. Osborne, Sewickley, Pa. 1,847,890; March 1.*

This spot welding machine welds articles of varying thicknesses without adjustment of any of the machine parts. The pressure may also be controlled on the articles to be welded, and means are provided for automatically making and breaking the flow of current during the interval of time the article is between the electrodes. The device has a frame mounted on a tubular bracket and is provided with a movable electrode. The fixed electrode is carried in a similar split bracket. The pressure cylinder actuates the movable electrode and is provided with a double acting piston which is coupled by means of the telescoping sections and of the connecting rod. A spring between the lower ends of the two sections provides a yieldable engagement between the movable electrode and the work. It firmly holds the pieces being welded during the welding period and also after the current ceases to flow to allow them to cool enough so that they will not pull apart after the pressure is released.

Hard Alloy, *by Karl Prinz zu Lowenstein and Wilhelm Muller, Berlin, Germany; assignors to Hirsch, Kupfer und Messingwerke Aktiengesellschaft, Finow (Mark) Germany. 1,847,617; March 1.*

The alloys covered by this patent are particularly hard and are also unaffected chemically so that they may be used as a suitable tool substance for the working of organic comopnds which would raise the temperature of the cutting tool. A preferred formula consists of 10% to 33% iron, 1% to 4% carbon, 48% to 35% tungsten, 16% to 11% molydenum, 16% to 5½% chromium, 4% to 3% cobalt, and 4% to 3% nickel. The ratio of the total percentage of tungsten and molybdenum to that of chromium and to that of cobalt and nickel should be 8:2:1.

Deoxidizer, *by Stanley R. Keith, Montclair, N. J. 1,846,114; Feb. 23.*

This invention relates to a deoxidizing compound to prevent lack of uniformity in alloys. Heretofore aluminum has been added to the molds in certain cases, but in certain instances, such as in the case of nickel-chromium alloys, it is dangerous because of the localized thermic reaction resulting. The present product is more uniform in operation and consists of approximately 1½ lb. of manganese, 3½ lb. of low carbon ferrotitanium (25% titanium) 2 lb. of ferrovanadium (35% to 40% vanadium), 10 lb. calcium, and 1 lb. of magnesium. Two pounds of the composition together with an additional pound of magnesum are used in each container and are sufficient generally for a 1200-lb. heat or less in a one-half ton furnace. If the heat exceeds 1500 pounds it is advisable to use two containers. The addition of this material forces the reactions to take place in a sequence thereby furnishing a control of the variables and thereby the harmful by-products may be removed.

Pure Iron, *by Herman Johan van Royen, Horde, Germany. 1,846,234; Feb. 23.*

This process produces substantially pure iron by overblowing a previously prepared iron bath and subsequently reducing it by means of a mixture of certain gases and finally carburizing it by directly introducing one or more saturated hydrocarbons. It is thus possible to manufacture iron and steel free from phosphorus, arsenic, sulphur and the like, and the metal is also free from slags which are inevitable when deoxidized according to the known processes. This type of iron and steel is also free from oxygen compounds. An essential feature of the invention is the employment of a reducing gas burning without increase of volume. Hydrogen is normally not suitable because its reducing action at higher temperatures decreases and the temperature of liquid iron is imperceptibly small. Carbon monoxide may be used as a reducing agent in the presence of carbon dioxide and a neutral gas such as nitrogen, the carbon dioxide quenchng the tendency of the monoxide to carbonize the bath and prevents explosions, while the neutral gas serves as a diluent and volume balancing means. The desired result obtained is that such a mixture burns without appreciable increase in volume, reducing the metal without carbonizing the same, and at the temperature of the iron bath, can entirely reduce the ferrous oxide present in the bath.

Inhibitor, *by Joseph M. Leaper, Philadelphia, assignor to E. F. Houghton and Co. 1,832,781; Nov. 17.*

In pickling iron and steel this inhibitor will reduce the pitting action of sulphuric acid and yet will efficiently remove scale and rust. It may be shipped in iron or steel containers with minimum corrosion. The patent adds an organic thio-sulphate to the pickling bath of the general formula $R.S.SO_2OM.$, where R is an organic radical and where M is a metal. One of the preferred combinations is an alkyl thiosulphate. A similar inhibitor is sodium benzyl thiosulphate. The proportion is about one lb. of compound to 3000 lb. of dilute acid.

(Continued on page 90)

Titanium Steel, *by Walther Mathesius and Hans Mathesius, Berlin-Charlottenburg, Germany. 1,847,350; March 1.*

Homogeneous titanium steel can be made in an economical way by this process. Ferrotitanium is produced separately from the manufacture of the iron bath and is added when molten to the finished iron bath. One way of carrying out the process is by deoxidizing the steel which will otherwise be prepared in the usual way and in the meantime the necessary amount of titanium thermit is filled into a second ladle, and a reaction of the thermit is caused in the ladle, so that the necessary amount of molten ferrotitanium is produced. It is also possible to combine the liquids in the channel following the tap-hole so that the molten and deoxidized steel is discharged into a strong current and the liquid steel imediately ignites the titanium thermit. The reaction of the thermit takes place on the surface of the steel bath which is energetically intermingled by the steel flowing from the steel ladle in a strong current. The titanium is thus uniformly alloyed to the steel collected. The titanium loss is reduced from 30 to 40%.